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(54) Orthogonal transform coding apparatus

Vorrichtung zur orthogonalen Transformationskodierung

Système de codage par transformation orthogonale

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- **NTC'78 CONFERENCE RECORD 1978 NATIONAL TELECOMMUNICATIONS CONFERENCE vol. 2, 3 December 1978, IEEE, NEW YORK, US; pages 1911 - 1916; A.G.TESCHER: 'Rate Adaptive Communication'**
- **PROCEEDINGS PATTERN RECOGNITION AND IMAGE PROCESSING, CHICAGO, US; 6 August 1979, IEEE, NEW YORK, US; pages 583 - 590; O.A. ZUNIGA ET AL.: 'Adaptive Image Data Compression'**

Description

This invention relates to an orthogonal transform coding apparatus for use in high-efficiency coding of picture signals.

High-efficiency encoding has been important with development of digital technology of picture signals. As the high efficiency encoding technology, orthogonal transform coding has been known, in which time sequential signals to be inputted are transformed to orthogonal components such as, for example, frequency components. As the orthogonal transformation, a Fourier transformation, a discrete cosine transformation (hereinafter abbreviatedly called DCT) and a Hadamard transformation are well known. Especially, DCT has been noticed as the orthogonal transformtechnology suitable for processing picture information.

An example of the high efficiency coding will be explained below by referring to Fig. 29 showing an example of a conventional high efficiency encoding apparatus using DCT. In Fig. 29, the reference numeral 1 indicates an input unit, 2 does a blocking unit, 3 a DCT unit, 4 an adaptive quantizer, 5 a variable length encoder, 6 a data buffer and 7 an output unit.

A digital image signal inputted from the input unit 1 is sent to the blocking unit 2 to be separated into blocks on a DCT unit basis. In the high efficiency encoding of image pictures, two dimensional DCT for a block constructed of a total of 64 picture elements made of horizontal 8 pixels and vertical 8 pixels is often used. The image signals thus blocked are subjected to the two dimensional DCT by the DCT unit 3 to transform into DCT components. The DCT components thus obtained are quantized by the adaptive quantizer 4, then subjected to variable length coding by the variable length encoder 5 and adjusted to a predetermined rate by the data buffer 6 and sent to the output unit 7.

The variable length encoding is a way of coding in which a codeword of higher generation probability is assigned by a shorter code and a codeword of lower generation probability is assigned by a longer code. Table 1 shows the correspondence between three bit data 0, 1, 2 -----, 7 and their variable length codes. In this example, numbers 0 and 1 are assigned by 2 bit code, 2 and 3 by three bit code, 4, 5, 6, and 7 are assigned by 4 bit code.

Table 1

Data	Variable length code
0	0 0
1	0 1
2	1 0 0
3	1 0 1
4	1 1 0 0
5	1 1 0 1
6	1 1 1 0
7	1 1 1 1

Since the DCT components show usually exponential distribution, the general probability of 0 and 1 is considerably larger than that of 4, 5, 6 and 7, the average bit number of them after encoding is smaller than 3 bit. In this case, however, it is noted that when the variable length encoding is used, the data rate after encoding may change depending on the picture quality. As a result, in the conventional apparatus shown in Fig. 29, in order to prevent an over flow or under flow in the data buffer 6, the adaptive quantizer 4 controls to increase the quantization width when the amount of data in the data buffer 6 is increased and to decrease the quantization width when the data amount is decreased.

The conventional high efficiency coding apparatus using DCT has problems which are as follows;

(1) Since the variable length encoding is used, even if one error bit occurs, code synchronization is disturbed, although it depends on the transmission line, and decoding of data is prevented. Such transmission error causes the picture quality to be largely deteriorated. Therefore, it is difficult to employ the conventional DCT apparatus particularly in devices in which transmission errors can occur in a high probability such as VTR.

(2) In order to maintain the data rate constant, conventionally there is used a feed-back system using a buffer. However, actual image data are unbalanced and it is difficult to obtain the optimum coding by the feed-back technique. Particularly, when the data amount of the front half of picture images is small and that of the rear half thereof is large, unnecessary data are assigned to the front half, the data amount in the rear half becomes short, resulting in a remarkable degradation in picture quality.

In order to solve these problems pointed out with the conventional apparatus, we invented and proposed an apparatus in which the data amount after encoding is estimated before quantizing to determine an optimum quantization and the variable length encoding can be completely achieved in a small range (see US Patent Application Serial No. 535,027 "An Apparatus for Orthogonal Transform Coding"), published as US Patent US-A-5,073,821.

An object of this invention is to provide a method of realizing this invention more efficiently.

European Patent Application EP-A-0267579 discloses an image coding system for monitoring an amount of information by forming a histogram. In an image coding system having a plurality of coding characteristics, such as quantization characteristics, a coding control circuit selects either one of the coding characteristics by forming a histogram in response to a sequence of coefficients resulting from a sequence of digital image signals, to monitor an amount of information in every one of predetermined intervals. The amount of information is calculated by summing up the coefficients in relation to every one of the coding characteristics. An optimum one of the coding characteristics is indicated by the coding control circuit to code the coeffieient sequence into a sequence of coded signals in accordance with the optimum coding characteristic. The coefficient sequence in each frame may be divided into a sequence of blocks each of which is judged to be either valid or invalid in relation to each coding characteristic.

The article "Rate Adaptive Communication" by Andrew G Tescher (NTC '78 Conf Rec 1978 National Telecoms Conf vol 2, 3 December 1978, (EEE, New York, US) discusses the theory of rate adaptive communication and buffering concepts. A utilization procedure for post-buffer control is presented, and examples with transform coding are discussed.

According to the present invention there is provided an orthogonal transform coding apparatus comprising:

large blocking means for assembling sample values of an input signal to form a large block of the sampled values;
small blocking means for dividing said large block into a plurality of small blocks;
orthogonal transform means for orthogonally transforming the sample values in each of the small blocks to obtain orthogonally transformed components;
a plurality of kinds of quantizers each for quantizing the orthogonally transformed components to obtain quantized data;
a data amount estimating means for estimating a data amount of coded data;
a quantizer selecting means for selecting a quantizer among the plurality of kinds of quantizers according to the data amount estimated by the data amount estimating means such that a total data amount of coded data in the large block becomes within a predetermined range;
variable length encoding means for encoding a quantized data by the quantizer selected by said quantizer selecting means to obtain actual coded data; and
transmission means for transmitting the actual coded data,

characterized in that: said large blocking means assembles sample values in a frame of an input signal to form a large block of the sampled values which is smaller than the frame;

said data amount estimating means estimates a data amount of coded data which would be obtained by variable length encoding the quantized data quantized by at least a part of the plurality of kinds of quantizers in each of the plurality of small blocks to obtain a plurality of data amount values corresponding to said at least a part of the plurality of quantizers with respect to the plurality of small blocks; and
said quantizer selecting means selects, from among the plurality of kinds of quantizers, a quantizer which gives an optimum data amount of the coded data with respect to each of the plurality of small blocks according to the data amount values estimated by the data amount estimating means such that a total data amount of coded data in respect of the large block becomes an optimum data amount which is either a maximum data amount not larger than an actually transmittable data amount or a minimum data amount not smaller than the actually transmittable data amount, and outputs a selection signal indicative of the selected quantizer.

Further, the quantizer selecting means may perform the steps of estimating the data amount obtained by the quantizer producing approximately the n/2th largest amount of coded data in a case where there are n candidates of quantizer, selecting only a quantizer producing a data amount smaller than a data amount produced by the quantizer which has been subjected to the data estimation in a case where the estimated quantized data amount is larger than a transmittable data amount, and on the contrary, in a case where the estimated quantized data amount is smaller than the transmittable data amount, selecting only a quantizer producing a data amount larger than the data amount produced by the quantizer which has been subjected to the data estimation, whereby the number of the candidates of quantizer is approximately halved, and repeats the abovementioned process so as to select an optimum quantizer.

Still further, the quantizer selecting means may perform the steps of dividing the. small blocks included in a large block into a front half including quantizers from the top one to the jth one and a rear half including the remainder,

selecting one quantizer from each of the front half and rear half as to produce nearest quantized values to each other, and transmitting the coded value and the information of the quantizers thus selected in the front half and rear half and of the number j.

In a case where there are n candidates of quantizer and m small blocks in a large block, supposing that the data amount in the jth small block of the ith quantizer is expressed as D(i,j), if D(i,j) ≧ D(i-1,j) when 1≦i<n, the data amount storing means stores first D(o,j) for the m small blocks into a memory, next, if S(i,j) = D(i,j) - D(i-1,j) when 1≦i<n, the data amount storing means stores S(i,j) into the memory successively in regard to i, the quantizer selecting means reads and adds D(o,j) in the m small blocks successively from O to m-1 in regard to j, then, to the result thus obtained are successively added S(i,j) in the order of S(0,0) S(0,1) ... S(0,m-1), S(1,0) ..., S(n-1,m-1), i and j with respect to the equation S(i,j) when the result thus obtained exceeds the transmittable data amount are detected, an ith quantizer is selected for the small blocks from the Oth up to (j-1)th or jth small block, and an (i-1)th quantizer is selected for the small blocks coming thereafter.

In a case where there are n kinds of quantizer and m small blocks included in a large block, supposing that the data amount in the jth small block of the ith quantizer is expressed as D(i,j), if D(i,j) ≧ D(i-1,j) when 1≦i<n, the data amount storing means stores S(i,j) = D(i,j) - D(i-1,j) for the m small blocks into a memory successively in regard to i, simultaneously stores a sum AD(i) which is the total data amount of the m small blocks corresponding to each quantizer in regard to i, the quantizer selecting means first compares the sum AD(i) with the transmittable data amount in regard to i of being 1≦i<n, the maximum AD(k) not exceeding the transmittable data amount and k are fetched, next, to said maximum AD(k) are successively added S(k+1,j) in the order of j = 0, 1 ... , m-1, j with respect to the equation S(k+1,j) when the result thus added exceeds the transmittable data amount is detected, a (k+1)th quantizer is selected for the small blocks from Oth to (j-1)th or jth small block, and a kth quantizer is selected for the small blocks coming thereafter.

The transmission means may re-arrange the quantized values of a small block in a transmission region made by the smallest square (hereinafter defined as transmission region) in the order from the low frequency value to the high frequency value in both horizontal and vertical directions so as to include all of non-zero values with the quantized value representing the lowest frequency component as one apex (origin), and transmits only the coded word of the quantized values included in the transmission region and information on the transmission region.

Also, the transmission means may re-arrange the quantized values of a small block in the order from the lowest frequency value to the highest frequency value in both horizontal and vertical directions, and transmit the coded word of the quantized values representing from the lowest frequency component up to the highest frequency component in both horizontal and vertical directions in the order from the coded word of the quantized values representing the low frequency value, and does not transmit the coded word of the quantized values coming after the quantized value representing the highest non-zero frequency value using the end signal or information capable of determining the position of the last quantized value. In this case, the variable length encoding means encodes the quantized value with the code length 2K+1 or 2K for the quantized value the figure number of the absolute value of which is K, and the data amount estimating means calculates the data amount of the coded quantized values in the small blocks of one quantizer according to the following equation

$$2 \times \Sigma Ki + M$$

where,

Ki is the figure number of the absolute value of the ith quantizer, and
M is the number of the quantized values to be transmitted.

Further, the variable length encoding means may encode the quantized value with the code length 1 for the quantized value O and the data amount estimating means calculates the data amount of the coded quantized values in the small blocks of one quantizer according to the following equation

$$\Sigma(Ni-1) + M$$

where, Ni is a code length of the ith quantized value, and M is the number of the quantized values to be transmitted.

The quantizing means may sort the orthogonally transformed components into r groups including from a group representing the high frequency level up to a group representing the low frequency level, and prepares s kinds of quantization widths, thus all of the quantizers performing quantization in combination with the r groups of the orthogonally transformed components with the s kinds of quantization widths.

Fig. 1 is a block diagram showing a digital VTR using this invention.

Fig. 2 is a block diagram showing an example of an orthogonal transform coding apparatus in accordance with this invention;

Fig. 3 to 5 are respectively block diagrams showing examples of the large block unit used in the apparatus of this invention.

Figs. 6 to 9 are respectively block diagrams showing examples of the orthogonal transform unit used in the apparatus of this invention.

Figs. 10 to 12 are respectively block diagrams showing examples of the transmission unit used in the apparatus of this invention.

Figs. 13, 16, 17 and 18 are respectively block diagram showing examples of the variable length encoding unit used in the apparatus of this invention.

Fig. 14 and 15 are respectively block diagrams showing examples of the data amount estimating unit used in the apparatus of this invention.

Figs. 19 to 22 are block diagrams and an explanatory drawing showing examples of the quantizing unit used in the apparatus of this invention.

Fig. 23 to 28 are block diagrams and flow charts showing examples of the quantizer selecting unit used in the apparatus of this invention.

Fig. 29 is a block diagram of a conventional orthogonal transform coding apparatus of the prior art.

First, outlines of a device in which this invention is applied will be shown by referring to the block diagram shown in Fig. 1, in which a digital VTR is used as an example. In Fig. 1, the reference numeral 8 indicates an input unit, 9 does an A/D converter, 10 an orthogonal transform coding apparatus according to this invention, 11 a magnetic head and 12 a magnetic tape. Television signals inputted from the input unit 8 are subjected to A/D conversion into sample values of digital picture signals by the A/D converter 9. The digital picture signal sample values thus converted are subjected to data compression by the orthogonal transform coding apparatus 10 thereby to be recorded through the magnetic head 11 in the magnetic tape 12. To employ the orthogonal transform apparatus of this invention in a picture recording device or picture transmission device such as digital VTR enables to decrease the data rate and provide a longer time recording.

Next, the details of this invention will be explained while showing embodiments. Fig. 2 is a block diagram of an orthogonal transform coding apparatus according to this invention.

In Fig. 2, the reference numeral 13 indicates an input unit, 14 does a large blocking unit, 15 a small blocking unit, 16 an orthogonal transform unit, 17 a data buffer, 18 a data amount estimating unit, 19 a quantizer selecting unit, 20 a quantizer, 21 a variable length encoder, 22 a transmission unit and 23 an output unit. Picture signals inputted from the input unit 13 are divided through the large blocking unit 14 into a plurality of large blocks each of which comprises a plurality of sample values. Each of large blocks is further divided through the small blocking unit 15 into a plurality of small blocks each being formed in a rectangular shape on the picture plane thereof. The small-blocked sample values are orthogonally transformed by the orthogonal transform unit 16. The orthogonal components thus orthogonally transformed are sent to the buffer 17 and data amount estimating unit 18 on a large block unit basis. In the data amount estimating unit 18, the data amount of coded orthogonal components in every small block is calculated for a plurality of quantizers prepared in advance, then one of the quantizers is selected for every small block by the quantizer selecting unit 19 based on the result of the calculation. At the same time, the orthogonal components inputted into the buffer 17 are delayed until the quantizer is selected. The orthogonal components sent from the buffer 17 are quantized in the selected one of the quantizers 20 by the quantizer selection unit 19 and the orthogonal components thus quantized are subjected to variable length coding by the variable length encoder 21. The quantized value coded in the variable length form is sent through the transmission unit 22 to the output unit 23.

As explained above, in this invention, by estimating the data amount before quantization, it becomes possible to select the optimum quantizer. Also, since it is possible to accurately control the data amount differently from the feedback control used in the prior art, it becomes possible to encode the data in the variable length form of a constant length of a small range, thus the variable length encoding is able to be employed in the digital VTR in which transmission errors occur frequently.

The detailed explanations will be made below on respective components shown in Fig. 2.

The large blocking unit 14 is explained first by referring to Fig. 3 showing a block diagram thereof. Fig. 3 is a block diagram showing a first example of the large blocking unit shown in Fig. 2.

In Fig. 3, 24 is an input terminal, 25 a memory, 26 an address controller, and 27 an output terminal. The sample value inputted from the input terminal 24 is sent to the memory 25 and outputted to the output terminal 27 according to the control of the address controller 26. As shown above, in the large blocking unit 14, the input signals are stored in the memory 25 and outputted for every large block. Fig. 4 is a diagram for explaining the operation of the large blocking unit shown in Fig. 2. In Fig. 4, shaded ones show small blocks. An assembly of the shaded small blocks forms a large block. In this embodiment, the large block is formed by assembling small blocks situated at various positions on the picture plane in a shuffling manner. As a result, the amount of information contained in the respective large

blocks is substantially equal to each other since the amount of information on the picture plane is scattered. Accordingly, even if the amount of information is irregularly positioned on the picture plane, it is possible to compress the data highly efficiently. Moreover, since the data rate of compressed codewords can be averaged, it is easy to control the data amount as to be constant on a large block unit basis. Such blocking can be made by controlling the output address in the address controller 26 shown in Fig. 3.

Fig. 5 is a block diagram showing a second example of the large blocking unit shown in Fig. 2. In Fig. 5, 28 is a luminance signal input terminal, 29 a first color difference signal input terminal, 30 a second color difference signal input terminal, 31 a frame memory, 32 an address controller and 33 an output terminal. Sample values inputted from the luminance signal input terminal 28, first color difference signal input terminal 29 and second color difference signal input terminal 30 are inputted to the frame memory 31 and outputted to the output terminal 32 according to the control by the address controller 32. In the second example shown in Fig. 5, each of the large blocks is formed by the luminance signals, the first color difference signals and second color difference signals containing them substantially at the same rate. In general, the amount of information of the luminance signals and the color difference signals is unbalanced. Since each large block contains the same rate of the luminance signals and the first and second color difference signals, it becomes possible to average the amount of information similar to the first example of the large blocking unit 14. In case where the input signals are R, G and B signals, the amount of information can be averaged by forming all of the large blocks so as to contain the R, G and B signals substantially at the same rate.

Next, the small blocking unit 15 will be explained below, which divides the sample values of each of the large blocks into blocks for orthogonal transformation. The circuit for the small blocking comprises a memory and an address controller substantially the same as the circuit for the large blocking as shown in Fig. 3. However, it is noted that the small blocking unit basically forms a two-dimensional block or a three-dimensional block including the time axis in accordance with the orthogonal transformation, thus being possible to use a decreased capacity of memory compared to that in the large blocking unit. In practical use, the large blocking unit and the small blocking unit may be constructed by one memory and one address controller to decrease the circuit scale, and the processing order of the small blocking and the large blocking can be exchanged. Similar to the large blocking unit, the small blocking unit may be formed by various shapes.

Next, the orthogonal transform coding unit 16 will be explained blow. For the sake of brevity, an example of orthogonal transformation is made by the discrete cosine transformation (DCT) using a small block consisting of 64 pixels of horizontal 8 pixels x vertical 8 pixels on the picture plane is typically explained. Fig. 6 is a block diagram showing an example of the orthogonal transform coding unit 16 shown in Fig. 2. In Fig. 6, 34 is an input terminal of the sample value of the small block, 35 a horizontal DCT unit, 36 a data arranging unit, 37 a vertical DCT unit and 38 an output terminal. The sample value small-blocked in the small blocking unit 15 in Fig. 2 is inputted through the input terminal 34 shown in Fig. 6 into the orthogonal transform coding unit 16 and discretely transformed in the horizontal direction by the horizontal DCT unit 35. The orthogonal components thus transformed in the DCT unit 35 are arranged in the vertical direction in the data arranging unit 36. The orthogonal components thus arranged are discretely transformed in the vertical direction in the DCT unit 37 and outputted to the output terminal 38. Both of the horizontal and vertical orthogonal components for every small block which have been subjected to the DCT transformation in the horizontal direction and vertical direction are inputted to the buffer 17 and the data amount estimating unit 18 shown in Fig. 3 in the order of the orthogonal components representing the low frequency range.

Although the above examples are described in connection with the two-dimensional DCT, in this invention, various kinds of DCT can be employed, three-dimensional orthogonal transformation containing time axis direction can be used. The simplest example of the three-dimensional orthogonal transformation is shown in Fig. 8.

In Fig. 8, 39 is an input terminal, 40 a field buffer, 41 a first field DCT unit, 42 a second field DCT unit, 43 an adder, 44 a subtracter, and 45 an output terminal. The signals inputted from the input terminal 19 are subjected to two-dimensional DCT transformation in the first DCT unit 41 and are also inputted simultaneously to the field buffer 40. The signal delayed by one field by the field buffer 40 are subjected to two-dimensional DCT in the second field DCT 42. The output signals from the first field DCT unit 41 and second field DCT unit 42 are added in the adder 43 and subtracted in the subtracter 44 and the results of both calculations are outputted to the output terminal 45. In the example shown in Fig. 8, the DCT transformed orthogonal components between two different fields situated at the same spatial position on the picture plane are added on one hand and subtracted on the other hand. In this case, the added components are quantized in the quantizer having a small quantization width and the subtracted components are quantized in the quantizer having a large quantization width, so that it becomes possible to compress the data amount while suppressing visual distortion of picture. To calculate the sum and difference of the data is a lowest dimensional (two-dimensional) orthogonal transformation, but it becomes possible to employ higher orthogonal transformation by using information of more fields.

A method which does not need the field buffer 40 can be provided in which the input of the three-dimensional DCT shown in Fig. 8 is made after being subjected to non-interlace transformation in the large blocking. At the same time, the three-dimensional DCT of (8 x 4 x 2) as shown in Fig. 8 and the two-dimensional DCT of (8 x 8) being subjected

to non-interlace transformation as shown in Fig. 7 can be switched depending on the movement between the fields.

The transmission unit 22 shown in Fig. 2 will be explained below. A first example of the transmission unit 22 is explained by referring to Fig. 9 showing the quantized values of the orthogonal components which are subjected to two-dimensional orthogonal transformation. The transmission unit 22 is adapted to transmit only the portion surrounded by the smallest rectangular portion (the portion surrounded by the solid lines in Fig. 9) containing all of only non-zero quantized values with the lowest frequency component (the quantized values at the position of horizontal 0 and vertical 0 and hereinafter called origin) in the horizontal direction and vertical direction as an apex. It is noted, in this case, that the data on the origin are always transmitted. Accordingly, the transmission range of this block (the rectangular range in Fig. 9) is decided by the position of the quantized value representing the non-zero highest frequency components in each of the horizontal and vertical directions. The number of quantized values to be transmitted is decided by the area of the transmission range, so that it can be easily calculated by the product of the position of the highest frequency in the horizontal direction and the highest frequency in the vertical direction. In this example, the information of the transmission range can be represented by the horizontal coordinate 3 bits and the vertical coordinate 3 bits, being 6 bits in total. As a result, the data amount after the coding of each small block is the sum of the variable-length coded word contained in the transmission range and the information of the transmission range. Next, the structure of the first example of the transmission unit 22 will be explained below by referring to Fig. 10.

In Fig. 10, 46 is an input terminal, 47 a horizontal direction high range detecting unit, 48 a vertical direction high range detecting unit, 49 a buffer, 50 a transmission range detecting unit, 51 a gate, and 52 an output terminal. The quantized values inputted from the input terminal 46 are applied to the horizontal direction high range detecting unit 47 and vertical direction high range detecting unit 48. In the horizontal direction high range detecting unit 47, a position is detected where the highest frequency component of non-zero quantized value in the horizontal direction exists. In the vertical direction high range detecting unit 48, a position is detected where the highest frequency component of non-zero quantized value in the vertical direction exists. The position thus detected is made as the origin of the rectangular shape shown in Fig. 10. Using the outputs of the horizontal direction high range detecting unit 47 and vertical direction high range detecting circuit 48, the transmission range detecting unit 50 sends only the quantized values in the transmission range to the output terminal 52 through the gate 51 among the quantized values to be delayed by the buffer 49. At the same time, the transmission range detecting unit 50 outputs the information representing the transmission range.

Fig. 11 shows the transmission order of a second example of the transmission unit of this invention. In the second example, the orthogonally transformed components are encoded in the order of the numbers shown in Fig. 11 from the lowest frequency component in both the horizontal direction and vertical direction in the small block and transmitted. The coded words after the quantized value representing the non-zero highest frequency are replaced by the codeword representing the end signal of transmission. By this process, since it is possible to concentrate the high range values which have high generation probability of 0 to the rear half, it makes possible to elongate the length of the consecutive 0. Instead of the end signal of transmission shown above, there may be used information representing the final coded word. Also, the transmission orders other than this are available in the practical use.

Fig. 12 shows the transmission unit of the second example. In Fig. 12, 53 is an input terminal, 54 a rearranging unit, 55 a buffer, 56 a final portion detecting unit, 57 an end signal insertion unit and 58 an output terminal. The quantized values inputted from the input terminal 53 are re-arranged in the order shown in Fig. 11 in the re-arranging unit 54 and sent to the buffer 55. The final portion detecting unit 56 detects the portion of the non-zero final quantized value among the quantized values thus re-arranged. The quantized values outputted from the buffer 55 have the final consecutive quantized values of 0 replaced by the end signal in the end signal insertion unit 56 according to the information from the final portion detecting unit 56 and sent to the output terminal 58.

Next, explanations will be made below on the variable length encoding unit shown in Fig. 2 by referring to Fig. 13 which is a block diagram of a first example thereof. In Fig. 13, 59 is an input terminal, 60 a ROM (Read Only Memory), and 61 an output terminal. The quantized values outputted from the input terminal 59 are encoded in a variable length manner by the ROM 60 and outputted to the output terminal 61. An example of the variable length encoding is explained below using the circuit shown in Fig. 13.

In a first example of the variable length encoding unit, such a code that the code length is 1 bit for the quantized value 0 is used. Namely, the code length Ni for the quantized value Ri is expressed as;

when $Ri = 0, Ni = 1.$

A first example of the data amount estimating unit for calculating the data amount when the variable length encoding unit as shown above is used is shown in Fig. 14. In Fig. 14, 62 is an input terminal, 63 a (code length - 1) counting unit, 64 a transmission range counting unit, 65 an adder, 66 a data amount summing unit, 67 an adder, and 68 an output terminal. The orthogonally transformed components inputted from the input terminal 62 are applied to the (code length - 1) counting unit 63 for calculating the value of (code length - 1). The output from the (code length - 1) counting unit 63 is added to the total data amount of the (code length - 1) of the previous (code length - 1) data amount outputted from the data amount summing unit 66 and the data amount of the total value is applied again to the data amount

summing unit 66. Simultaneously, in the transmission range counting unit 64, the number of codewords to be actually transmitted is counted and the value thus counted is added to the sum of the (code length - 1) outputted from the data amount summing unit 66 in the adder 67 and then, outputted to the output terminal 68. The first variable length encoding unit makes code length as 1 for the quantized value of 0. As a result, the value of the (code length - 1) becomes 0. Accordingly, the sum of the (code length - 1) for the all input signals and the number of codewords to be transmitted is equal to the sum of the code length of the signal to be transmitted. Therefore, the calculation of the data amount and the calculation of the transmission range can be made simultaneously, there does not need to detect the transmission range in advance. As a result, it becomes possible to halve the time of the data amount estimation.

Next, a second example of the variable length encoding unit shown in Fig. 2 will be explained using Table 2. The quantized values to be inputted are expressed in binary form as;

(S, X_7, X_6, X_5, X_4, X_3, X_2, X_1, X_0). Wherein S is a bit for the sign of plus and minus and X_0 to X_7 represent binary value of the absolute value of the quantized values. X_7 is the most significant position and X_0 is the least significant position. The quantized values represented by 9 bits are encoded in a variable length manner according to the rule shown in Table 2. In this example, it can be encoded into the variable length code without any complicated calculation. As a result, it becomes possible to encode without using ROM shown in Fig. 13.

Table 2

Variable length encoding	
Quantized value to be inputted	Variable length code word
$X_0=\cdots=X_7=0$	0
$X_0=1,\ X_1=\cdots=X_7=0$	10S
$X_1=1,\ X_2=\cdots=X_7=0$	$110X_0S$
$X_2=1,\ X_3=\cdots=X_7=0$	$1110X_0X_1S$
$X_3=1,\ X_4=\cdots=X_7=0$	$11110X_0X_1X_2S$
$X_4=1,\ X_5=\cdots=X_7=0$	$111110X_0X_1X_2X_3S$
$X_5=1,\ X_6=\cdots=X_7=0$	$1111110X_0X_1X_2X_3X_4S$
$X_6=1,\ X_7=0$	$11111110X_0X_1X_2X_3X_4X_5S$
$X_7=1$	$11111111SX_0X_1X_2X_3X_4X_5X_6$

In the second example, the code length Ni for the number of figures Ki of the absolute value of the quantized value is expressed as;

$$Ni = 2 \times Ki + 1.$$

Thus, the code length for the quantized values can be easily calculated.

Fig. 15 is a second example of the data amount estimating unit for the second variable length encoding unit. In Fig. 15, 69 is an input terminal, 70 a figure number counting unit, 71 a transmission range counting unit, 72 an adder, 73 a figure number summing unit, 74 a doubler, 75 an adder and 76 an output terminal. The figure number counting unit 70 calculates the figure number of the absolute value of the quantized values of the orthogonally transformed components inputted from the input terminal 69. The output of the figure number counting unit 71 is added in the adder 72 to the total value of the respective figure numbers which has been summed for the previous signals before outputted from the figure number summing unit 73 and the summed value thus obtained is inputted again to the figure number summing unit 73. Simultaneously, in the transmission range counting unit 71, the number of codewords to be actually transmitted is calculated and the calculated number is added to the value obtained by doubling through the doubler 74 the total number of figures outputted from the figure number counting unit 73 in the adder 75 and outputted to the output terminal 76. In the second variable length encoding unit, since the code length is expressed as (twice the figure number of the quantized value + 1), the data amount can be easily estimated.

Next, a third example of the variable length encoding unit shown in Fig. 2 will be explained below. Almost all orthogonally transformed components are 0. As a result, the probability of consecutive generation of 0s of the quantized values is high. Thus, by encoding the length of the consecutive 0s of the quantized values in the run length code, the data amount can be compressed (in this case, the run length shows the length of consecutive 0s). Furthermore, by encoding the length of consecutive 0s of the quantized values and the first non-zero quantized value following thereto

collectively as one codeword, more effective compression becomes possible. This coding method is called 2 dimension encoding. The third variable length encoding unit is explained by referring to Fig. 16. In Fig. 16, 77 is an input terminal, 78 a 0 detecting unit, 79 a 0 run length detecting unit, 80 a 2 dimension encoding unit, and 81 an output terminal. The quantized values inputted from the input terminal 77 are subjected to the detection whether or not each of the quantized value is 0 in the 0 detecting unit 78. If the quantized value is 0, the previous run length value summed in the 0 run length detecting unit 79 is added by 1. When non-zero quantized value is detected in the 0 detecting unit 78, the 2 dimension encoding unit 80 performs the 2 dimension encoding by using the non-zero quantized value thus detected and the 0 run length value obtained from the 0 run length detecting unit 79 and outputs the 2 dimension code thus obtained to the output terminal 81, while the run length value summed in the 0 run length detecting unit 79 is reset to 0. So processed as above that even when the generation probability of 0 is high, the data amount can be more efficiently compressed.

Next, a fourth example of the variable length encoding unit as shown in Fig. 2 will be explained below. In general, in picture information, energy is large in the low frequency component and decreases as the frequency component becomes high. As a result, even in case of the orthogonal components which have been orthogonally transformed, the low frequency component (the component on the upper right in Fig. 7) has a comparatively large value. Accordingly, the data amount reduction effect of the variable length encoding on the orthogonal component representing the low frequency becomes small. In the fourth variable length coding unit, the fixed length encoding is applied to the orthogonal component thus representing the low frequency and on the other hand, the variable length encoding is applied to the orthogonal component representing the medium/high frequency. This example is explained by referring to Fig. 17. In Fig. 17, 82 is an input terminal, 81 a switch, 84 a fixed length encoding unit, 85 a variable length encoding unit, 86 a low frequency range detecting unit, and 87 an output terminal. The quantized value of the orthogonal components inputted from the input terminal 82 is judged in the low frequency range detecting unit 86 whether it is of the low frequency or the medium/high frequency. The low frequency range detecting unit 86 can be made of a counter for the practical purpose. When the low frequency range detecting unit 86 detects it as to be low, the quantized value of the orthogonal components is inputted through the switch 83 to the fixed length encoding unit 84 for encoding in the fixed length form and outputted to the output terminal 87. On the other hand, when it detects it as to be medium or high, the quantized value of the orthogonal components is inputted through the switch 83 to the variable length encoding unit 85 for encoding in the variable length form and outputted to the output terminal 87. With the structure as shown above, it becomes possible to encode only the low frequency portion in the fixed length form.

Next, a fifth example of the variable length encoding unit shown in Fig. 2 will be explained below. As explained in the fourth variable length coding unit, in this example, the orthogonally transformed component has different distributions in the low and high frequency ranges. As a result, for the low frequency range, the code length for small quantized values is set to be comparatively large and that for large quantized values is set to be comparatively small, and on the other hand, for the high frequency range, the code length for small quantized values is set to be comparatively small and that for large quantized values is set to be comparatively large, so that the data amount can be more efficiently reduced. The fifth variable length encoding unit will be explained by referring to Fig. 18. In Fig. 18, 88 is an input terminal, 89 a switch, 90 a first variable length encoding unit, 91 a second variable length encoding unit, 92 a low frequency range detecting unit, and 93 an output terminal. The quantized value of the orthogonal components inputted from the input terminal 88 is judged in the low frequency range detecting unit 92 whether it is of the low frequency range or the high frequency range. The low frequency range detecting unit 92 can be made of a counter for the practical purpose. When detected as to be of the low frequency range, the quantized value of the orthogonal components is sent through the switch 89 to the first variable length encoding unit 90 for encoding in the variable length form and outputted to the output terminal 93. On the other hand, when detected as to be of the high frequency range, the quantized value of the orthogonal components is sent through the switch to the second variable length encoding unit 91 for encoding in the variable length form and outputted to the output terminal 93. With the structure as above, the variable length encoding can be applied as to be adapted to the low frequency range and high frequency range. Also, in this example, the quantized value is divided into two, the low and high frequency ranges, but to can be divided into more ranges, and the variable length encoding can be applied as to be adapted to each range thus divided.

Next, the quantizing unit of this invention will be explained below. Fig. 19 is a first example of the quantizing unit shown in Fig. 2. In Fig. 19, 94 is an input terminal, 95 a switch, 96 a $\sqrt{2}$ multiplier, 97 a bit shifter 98 a controller, 99 a rounding unit and 100 an output terminal. The signal inputted from the input terminal 94 is selected by the switch 95 according to the control of the controller 98 whether it is subjected to $\sqrt{2}$ multiplication in the $\sqrt{2}$ multiplier 96 and sent to the bit shifter 97 or directly sent to the bit shifter 97. In the bit shifter 97, the signal thus sent is shifted by a specific number of bits according to the control of the controller 98, then rounded in the rounding unit 99 and sent to the output terminal 100. With the arrangement in this example shown in Fig. 19, the multiplication (or the division) of various constants can be realized through the controller 98 by combining the $\sqrt{2}$ multiplier 96 and the bit shifter 97. As a result, a quantizing unit having a plurality of the quantization widths (multiplier factor) can be easily realized. In addition, in Fig. 19, an arrangement without using the switch 95 and $\sqrt{2}$ multiplier 96 is possible realizable. In such case, as the

quantizing unit is made of a bit shifter only, it can be realized further easily.

A second example of the quantizing unit shown in Fig. 2 will be explained below. Fig. 20 shows that the orthogonal components of (8 x 8) DCT blocks explained in Fig. 7 are divided into four ranges excepting DC components (shaded area in Fig. 20). The numerals shown in Fig. 20 indicate the numbers of respective ranges. Generally, human vision is sensitive to the distortion of low frequency components and insensitive to that of high frequency components. As a result, by quantizing the high frequency component in larger quantization width, the compression of the data amount can be improved while making visual deterioration small. In the second quantizing unit, the quantization width is controlled by range shown in Fig. 20. Table 3 shows the relation of the range and quantization. With the quantization shown in Table 3, 16 kinds of quantizing means are available (columnar direction of Table 3), and each quantizing means has four frequency ranges as shown in Fig. 20 (row direction of Table 3). The fractions shown in Table 3 each indicates the multiplier factor of multiplication (the inverse number of quantization range) to be executed the quantization for a quantizing means (column) and range (row). For example, in the fifth quantizing means, the multiplication of 1/4 is executed for the orthogonal component in the second range (quantized with the quantization width of 4). As seen from table 3, the multiplier factor to be actually employed in this example has five kinds ranging from 1/16 to 1. As a result, the combination of five kinds of the quantization width and four kinds of range makes 16 kinds of the quantizing means realizable. By introducing such quantizing means into this example, a large number of quantizing means can be realized despite of using simple quantization by use of a bit shifter, so that the data amount can be more precisely controlled. In addition, by making the quantization width larger for the high frequency range, the visual picture deterioration can be reduced.

Referring to the data amount estimation for the quantizing means shown in Table 3, the data amounts for the five kinds of quantization width are calculated independently for every four kinds of range, and then the results thus calculated can be combined to calculate the data amounts for the 16 kinds of quantizing means. Therefore, the circuit scale of the data amount estimating unit can be made small.

Table 3

	Quantization			
Range	1	2	3	4
0	1 / 8	1 / 16	1 / 16	1 / 16
1	1 / 8	1 / 8	1 / 16	1 / 16
2	1 / 8	1 / 8	1 / 8	1 / 16
3	1 / 8	1 / 8	1 / 8	1 / 8
4	1 / 4	1 / 8	1 / 8	1 / 8
5	1 / 4	1 / 4	1 / 8	1 / 8
6	1 / 4	1 / 4	1 / 4	1 / 8
7	1 / 4	1 / 4	1 / 4	1 / 4
8	1 / 2	1 / 4	1 / 4	1 / 4
9	1 / 2	1 / 2	1 / 4	1 / 4
10	1 / 2	1 / 2	1 / 2	1 / 4
11	1 / 2	1 / 2	1 / 2	1 / 2
12	1	1 / 2	1 / 2	1 / 2
13	1	1	1 / 2	1 / 2
14	1	1	1	1 / 2
15	1	1	1	1

Fig. 21 shows a third example of the quantizing unit shown in Fig. 2. In Fig. 21, 101 is an input terminal, 102 a quantizer, 103 a non-zero detecting unit, 104 a reversed quantizer, 105 a subtracter, 106 an adder, 107 a quantization error summing unit, and 108 an output terminal. The signals inputted from the input terminal 101 are quantized in the quantizer 102 and sent to the output terminal 108. On the other hand, the outputs from the quantizer 102 are sent to the non-zero detecting unit 103 to detect whether or not the output is 0. If it is not 0, the non-zero output is sent to the reversed quantizer 104 to be subjected to reversed quantization. The output thus reversely quantized outputted from

the reversed quantizer 104 is sent to the subtracter 105 to calculate the quantization error between the thus reversed value and the value of the input signal. The quantization error thus calculated is added in the adder 106 to the total value of the previous quantization errors of the quantized values outputted from the quantization error summing unit 107 and sent again to the quantization error summing unit 107. In such a manner as shown above, the total quantization errors of one small block are summed and outputted to the output terminal 108. In this example of the quantization, an average value of the quantization errors of non-zero quantized values for every small block is calculated and outputted with the quantized value. The quantization errors in the orthogonal transformation are often uneven on a small block basis. Therefore, the quantization errors are calculated for every small block and the correction is made using the data of the quantization errors thus calculated at the time of the decoding thereby enable to improve the quantization distortion. The signals representing the quantization error for one small block to be transmitted at this time can be represented by a few bits, thus increment of the data amount being very small.

In a fourth example of the quantizing unit shown in Fig. 2, signals situated on the same positions in the frame direction or the field direction are quantized by separate quantizers of different quantizing properties for every frame or every field. The fourth quantizing unit will be explained below using Fig. 22. In Fig. 22, 109 an input terminal, 110 an adder, 111 an offset generating unit, 112 a frame number input unit, 113 a quantizer, 114 a quantization controller and 115 an output terminal. The orthogonal components inputted from the input terminal 109 are added to the offset value outputted from the offset generating unit 111 in the adder 110 and quantized in the quantizer 113 in accordance with the information obtained from the quantization controller 114 and sent to the output terminal 115. On the other hand, in the offset generating unit 111, the offset value is generated in accordance with the present frame number inputted from the frame number input unit 112 and the information inputted from the quantization controller 114. For example, when the quantization is made in a large quantization width in accordance with the information from the quantization controller 114, the offset value is made large, and different offset values are outputted in cases that the frame number is odd and even. By using the fourth quantizing unit, it becomes possible to provide the quantization error with a variation for every frame. As a result, in the still picture, it becomes possible to cancel the quantization error on a frame to frame basis.

In addition, due to the fact that the quantization error differs on a frame to frame basis, the distortion can be scattered time to time, so that the block distortion can be decreased. In this example, the rounding operation is controlled by means of the offset value to provide the quantization property with a variation, however, it can be realized by varying the quantization property itself of the quantizer in a frame to frame manner.

Next, the quantizer selecting unit shown in Fig. 2 will be explained. A first example of the quantizer selecting unit operates in such a manner as described below. Namely, when there are n candidates of quantizer, the data amount after encoding is estimated for the quantizer producing about n/2th-largest amount of coded data. When the estimated quantized data amount is larger than a transmittable value, the candidate quantizers are limited to quantizers that produce a data amount smaller than the data amount produced by the selected quantizer for performing the data amount estimation. On the other hand, when the estimated data amount is smaller than the transmittable value, the candidate ones are limited to quantizers that produce a data amount larger than the data amount by the selected quantizer for performing the data amount estimation. In this way, the number of the candidate quantizers is approximately halved by one data amount estimation and the above-mentioned operation is repeated, thus the optimum quantizers can be selected. By this method, it is possible to select the optimum quantizers by performing about $\log_2 n$ times of data amount estimation when there are n candidate quantizers. An example of the process described above is shown in the flow chart form in Fig. 23. In which, 116 indicates a start step, 117 does a second quantization estimation, 118 a third quantization estimation, 119 and 120 each an overflow detection, 121 a first quantization output, 122 a second quantization output and 123 a third quantization output. In this example, there are provided with three quantizing units, larger quantized values are generated in the order of the third quantization, second quantization and first quantization for the same input value. First, the second quantization estimation is made in the step 117 using the second quantization for the input signal. Then, the process goes to the step 119 for detecting whether or not the data amount for the second quantization obtained in the second quantization step 117 exceeds the transmittable limit. In this case, if exceeding, the first quantization is selected to be ended. On the other hand, if not exceeding, the process goes to the step 118 for estimating the data amount using the third quantization. Then, the process goes to the step 120 for detecting whether or not the data amount quantized in the third quantization exceeds the transmittable limit. In this case, if detected to be exceeded, the second quantization is selected to be ended. On the other hand, if detected not to be exceeded, the process goes to the step 123 for performing the third quantization and goes to the end. As explained above, in the first example of the quantizer selecting unit, it becomes possible to decrease greatly the calculation amount for the data amount estimation. Also, in this example, such a quantizer that produces the maximum data amount not exceeding the transmittable limit is selected, however, there may be selected such a quantizer that produces the minimum data amount not less than the transmittable limit.

In a second example of the quantizer selecting unit, the small blocks contained in one large block are divided into two, namely the front half and rear half, with the boundary of the jth small block counted from the front top one. For

these two groups thus divided, two quantizers having the nearest data amount after encoding are selected. In transmitting, the information of the values of the order numbers i and j of the selected quantizer to be used in the front half or the rear half are encoded and transmitted. In the second example, only two kinds of the quantizing unit are used in one large block. By this limitation, since the number of the combination of the quantizers in the large block can be largely decreased, leading to the decrease of the calculation amount. In addition, the two kinds of the quantizing unit are selected from the groups of the small blocks consisting of the front half and rear half divided in the large block. As a result, the information representing what quantizer is to be used may be expressed only by the boundary of the front half and rear half (namely, the jth small block) in the large block, so that the information to be transmitted can be made small in amount.

Here, a concrete example will be shown. It is assumed that there are 16 kinds of the quantizer and one large block consists of 30 small blocks. Also, it is assumed that the data amount of the jth small block in the ith quantizer is expressed as D(i,j) and the following S(i,j) is defined as;

$$S(i,j) = D(i,j) - D(i-1,j)$$

(where it is assumed that D(-1,j)

= 0 and $D(i,j) \geqq D(i-1,j)$)

Using the above equation, calculation is made for 30 small blocks to obtain Table 4 and stored in a memory.

Table 4 Data amount

	0	1	2 · · · j · · · 29
0	S (0, 0)	S (0, 1)	S (0, 2) · · · S (0, j) · · · S (0, 29)
1	S (1, 0)	S (1, 1)	S (1, 2) · · · S (1, j) · · · S (1, 29)
·	·	·	· · ·
i	S (i, 0)	S (i, 1)	S (i, 2) · · · S (i, j) · · · S (i, 29)
·	·	·	· · ·
15	S (15, 0)	S (15, 1)	S (15, 2) · · S (15, j) · · S (15, 29)

The optimum values i and j are calculated according to the flow chart shown in Fig. 24 using the data amount shown in Table 4. In Fig. 24, 124 indicates a start step, 125 an initial value setting, 126 a total data amount calculation, 127 an overflow detection, 128 an increment, 129 a j detection, 130 an i increment, 131 an i detection, 132 an overflow processing, and 133 an output terminal.

First, in the step 125, the initial value is set as the total data amount TD = -CD (CD is the target data amount after compression) and i = j = 0. In the step 126, the total data amount is calculated by the equation TD = TD + S(i,j). In the step 127, whether or not the value of TD is larger than 0 is detected, in case of being more than 0, the process goes to the step 133 to output the values i and j and the process goes to the end. In case when the value of TD is negative, the process goes to the step 128 to calculate j = j + 1. The process goes to the step 129 to detect whether or not the value of j is 30, in case of not being 30, the process goes to the step 126. In case of being 30, the process goes to the step 130 to calculate i = i + 1 and j = 0. In the i detection step 131, whether or not the value of i is 16, in case of not being 16, the process goes to the step 126. On the other hand, in case of being 16, the process goes to the step 132 for making i = 15 and j = 29, and the values i and j are outputted in the step 133 and the process goes to the end. By this way, the values i and j can be calculated. Since the values i and j can be expressed by 4 bits and 5 bits, respectively, the information what quantizer is selected can be transmitted by 9 bits for each large block.

A second example of the second quantizer selecting unit will be explained below. In this example, one large block consists of 30 small blocks and there exist 16 kinds of the candidate quantizer. In addition, assuming that the data amount of the jth small block in the ith quantizer is expressed by D(i,j), similar to in the first example, the following S (i,j) is defined as;

$$S(i,j) = D(i,j) - D(i-1,j)$$

$$AD(i) = \sum_{j=0}^{2a} D(i,j)$$

With the equation shown above, calculations are made for obtaining Table 5 and stored in a memory in the same manner as in obtaining Table 4. In this example, using the data amount tabulatedly shown in Table 5 and according to the flow chart shown in Fig. 25, the optimum values of i and j are determined. In Fig. 25, 134 indicate a start step, 135 an initial i value setting, 136 a first data amount comparison, 137 an i decrement, 138 an overflow detection, 139 a TD/ initial j value setting, 140 a TD increment, 141 a second data amount comparison, 142 a j increment, 143 a j overflow detection, 144 a j decrement, 145 a j setting and 146 an output terminal.

Table 5 Data amount

	0	1 ・・・ j ・・・ 29	
0	–	– – –	AD (0)
1	S (1.0)	S (1.1) ・・・ S (1.j) ・・・ S (1.29)	AD (1)
・	・	・ ・ ・	・
i	S (i.0)	S (i.1) ・・・ S (i.j) ・・・ S (i.29)	AD (i)
・	・	・ ・ ・	・
15	S (15.0)	S (15.1) ・・・ S (15.j) ・・ S (15.29)	AD (15)

Next, the operation of the flow chart shown in Fig. 25 will be explained. First, in the initial i value setting step 135, the initial value i is set to 15. In the step 136, AD(i) and CD (the data amount actually transmittable) are compared, and

if AD(i) ≦ CD, the process goes to the step 139, and
if AD(i) > CD, the process goes to the step 137 to calculate i = i-1, and goes to the step 138.

In the step 138, whether or not the value of i is 0, and if i = 0, the process goes to the step 145 to set the value J to 29, and the values i and j are outputted to the step 146. On the other hand, if i ≠ 0, the process goes to the 136. In the step 139, TD = AD(i) and j = 0 are set. Then, in the step 140, TD = TD + S(i,j) is calculated and the process goes to the step 141. In the step 141, TD and CD are compared, and
if TD > CD, the process goes to the step 144, and if TD ≦ CD, the process goes to the step 142 to calculate j = j + 1 and goes to the step 143.

In the step 143, whether or not the value j is 30, and

if j = 30, the process goes to the step 144, and
if j ≠ 30, the process goes to the step 140.

In the step 144, j = j-1 is calculated and the values i and j are outputted to the output terminal step 146.

Thus, the values i and j can be obtained. Also, in this example, since the values i and j can be expressed by 4 bits and 5 bits, respectively, the information on what quantizer is selected can be transmitted by 9 bits for every large block. In addition, in this example, the value i is determined first and then, the value j is determined, so that the calculation amount can be decreased and the calculation time can be shortened.

A third example of the quantizer selecting unit detects a dynamic range for each small block, and for the small block detected to have a large dynamic range, a quantizer having a large quantization width is selected, and for the small block detected to have a small dynamic range, a quantizer having a small quantization width is selected. In the

transmission, the information on what quantizer is selected is encoded for each small block and transmitted. Fig. 26 shows an example of the third quantizer selecting unit. In Fig. 26, 147 is an input terminal, 148 a dynamic range detecting unit, 149 a quantizer sorting unit, and 150 an output terminal. The data for each small block inputted from the input terminal 147 is sent to the dynamic range detecting unit 148 to detect the dynamic range thereof. As a method of performing such detection, there exists such a technique that the detection is made by the value of the orthogonal component whose absolute value is maximum in the small block. The quantizer sorting unit 149 sorts the quantizers for such small block in response to the dynamic range thus detected and the result thus obtained is outputted to the output terminal 150. For example, if the small block is sorted into four kinds according to the size of the dynamic range, the output from the quantizer sorting unit 149 can be expressed by 2 bits. Also, as an actual method of selecting the quantizer, the quantization width of the small block is made large as the dynamic range thereof becomes large. As a result, if the quantizer as shown in Table 3 is used, the small block having larger dynamic range is assigned a quantizer having a small number. Also, as a method of making the data amount constant, the second quantizer selecting unit is possibly applied. In this case, if Table 4 or 5 is to be prepared, it can be realized by shifting the position where the data is to be written for each small block in the columnar direction in advance. That is, in preparing Table 4, a small block having large dynamic range shifts the corresponding row thereto downward to be written, and on the other hand, a small block having small dynamic range shifts the corresponding row thereto upward to be written. By this way, by detecting Table 4 in the columnar direction, in the small block having large dynamic range, the data amount of a quantizer having large quantization width is written and on the other hand, the small block having small dynamic range has the data amount of a quantizer having small quantization width written. As a result, by applying such an algorithm as shown in Fig. 24 or 25 in accordance with the table prepared as above, the combination of the quantizers becomes possible to make the data amount constant. This method will be explained by referring to Fig. 27. In Fig. 27, 151 is an input terminal, 152 a memory, 153 an address generating unit, and 154 a quantizer sorting unit. The data amount on a small block unit basis inputted from the input terminal 151 is stored in the memory 152 in accordance with the address generated by the address generating unit 153. The address generating unit 153 controls the address for every small block in accordance with the signal inputted from the quantizer sorting unit 154. This example describes the method of controlling the input address of the memory, but the same effect can be obtained by controlling the output address of the memory. In general, in case of a picture having large dynamic range, the visual picture deterioration thereof can be difficult to detect and in case of a picture having small dynamic range, it can be easily detected. As a result, by assigning a quantizer having large quantization width to such a small block that the maximum value of the absolute value of the quantized value (dynamic range) is large, the data amount can be largely compressed while suppressing the visual picture deterioration.

A fourth example of the quantizer selecting unit will be shown below. In the fourth example, the quantizer selecting unit is designed or adapted to select a quantizer having large quantization width for the signals which are difficult to detect the visual picture deterioration and a quantizer having small quantization width for the signals which are easy to detect the visual picture deterioration for the brightness signal and two color difference signals. This will be explained below by referring to Fig. 28. In Fig. 28, 155 is a number input terminal for every small block, 156 a brightness signal, first color difference signal and second color difference signal judging unit, 157 a quantizer sorting unit and 158 an output terminal. In response to the number of a small block (processing order) inputted from the input terminal, the unit 156 judges whether the small block thus inputted is of the brightness, first color difference or second color difference signal. In the quantizer selecting unit 157, in accordance with the result of judgement shown above, the quantizer corresponding to the small block is sorted and the result thus sorted is outputted to the output terminal 158. Also, in the actual selection of the quantizer, it can be realized by controlling the address to the memory and applying the quantizer selecting unit shown in the second example as shown in Fig. 27.

As explained above, the quantizer selecting unit as designed as above of this invention makes it possible to make the circuit scale small in calculating the data amount by decreasing the figure number of operations. In this case, some errors may be generated between the estimated data amount and the actually transmittable data amount, however, the possibility to vary the quantized values to be selected by the errors thus generated is considerably small. As a result, almost no deterioration in picture quality results and a reduction in circuit scale becomes possible.

Finally, the process order of the components including the large blocking, small blocking and orthogonal transform units may be changed variously other than the orders shown in the above-mentioned examples.

With the arrangement as described above, this invention makes possible that the coded data amount is read in advance thereby to quantize it always using an optimum quantizer. Also, different from the conventional feed-back control technology, the data amount can be precisely controlled, so that such a variable length encoding can be provided that the code length becomes constant in a small range. Accordingly, even in case of an equipment in which transmission line errors may be often occurred as in, for example, a digital VTR, it is possible to use the variable length encoding. In addition, use of the quantizer, data amount estimating unit or the like according to this invention makes it possible to make the equipment in comparatively small circuit scale, which means that the practical effects of this invention are extremely large.

Claims

1. An orthogonal transform coding apparatus comprising:

   large blocking means (14) for assembling sample values of an input signal to form a large block of the sampled values;
   small blocking means (15) for dividing said large block into a plurality of small blocks;
   orthogonal transform means (16) for orthogonally transforming the sample values in each of the small blocks to obtain orthogonally transformed components;
   a plurality of kinds of quantizers (20) each for quantizing the orthogonally transformed components to obtain quantized data;
   a data amount estimating means (18) for estimating a data amount of coded data;
   a quantizer selecting means (19) for selecting a quantizer (20) among the plurality of kinds of quantizers according to the data amount estimated by the data amount estimating means (18) such that a total data amount of coded data in the large block becomes within a predetermined range;
   variable length encoding means (21) for encoding data quantized by the quantizer (20) selected by said quantizer selecting means (19) to obtain actual coded data; and
   transmission means (22) for transmitting the actual coded data,

   characterized in that: said large blocking means (14) assembles sample values in a frame of an input signal to form a large block of the sampled values which is smaller than the frame;

   said data amount estimating means (18) estimates a data amount of coded data which would be obtained by variable length encoding the quantized data quantized by at least a part of the plurality of kinds of quantizers (20) in each of the plurality of small blocks to obtain a plurality of data amount values corresponding to said at least a part of the plurality of quantizers with respect to the plurality of small blocks; and
   said quantizer selecting means (19) selects, from among the plurality of kinds of quantizers (20), a quantizer which gives an optimum data amount of the coded data with respect to each of the plurality of small blocks according to the data amount values estimated by the data amount estimating means (18) such that a total data amount of coded data in respect of the large block becomes an optimum data amount which is either a maximum data amount not larger than an actually transmittable data amount or a minimum data amount not smaller than the actually transmittable data amount, and outputs a selection signal indicative of the selected quantizer.

2. An orthogonal transform coding apparatus according to claim 1, wherein the data amount estimating means (18) includes a data amount storing means for storing the plurality of data amount values estimated by the data amount estimating means.

3. An apparatus according to Claim 1 or 2, wherein said quantizer selecting means (19) first finds, among n kinds of quantizers (20), a quantizer which gives a n/2-th largest amount of coded data, where n is the number of quantizers to be searched to find an optimum quantizer among the plurality of kinds of quantizers, and then determines that quantizer candidates to be searched next are only quantizers which give amounts of coded data each being smaller than the n/2-th largest amount of data if the n/2-th amount of data is larger than a transmittable amount of data or only quantizers which give amounts of coded data each being larger than the n/2-th larges amount of data if the n/2-th amount of data is smaller than the transmittable amount of data, said quantizer selecting means repeating these operations until an optimum quantizer to be selected is found.

4. An orthogonal transform coding apparatus as claimed in Claims 1,2 or 3, wherein said quantizer selecting means (19) includes means for dividing the small blocks included in a large block into a front half including quantizers (20) from a top one to a jth one and a rear half including the remainder, and means for selecting one quantizer from each of the front half and rear half so as to produce nearest quantized values to each other, and means for coding and transmitting information of the quantizers thus selected in the front and rear halves and of the number j.

5. An orthogonal transform coding apparatus as claimed in Claim 2, wherein when there are n quantizer candidates and m small blocks in one large block, and the amount of data in the jth small block of the ith quantizer is expressed as D(i,j), if D(i,j) ≥ D(i-1,j) when 1 ≤ i < n, said amount of data storing means first stores D(o,j) for said m small blocks in a memory, and then, if S(ij) =D(i,j) - D(i-1,j) when 1 ≤ i < n, said data amount storing means successively stores S(i,j) in said memory with regard to i, and said quantizer selecting means (19) reads and successively adds

D(o,j) in said m small blocks from 0 to m-1 with regard to j, and then, to the result thus added are successively added S(i,j) in the order of S(0,0), S(0,1) ..., S(0,m-1), S(1,0)..., and S(n-1,m-1), i and j with respect to the equation S(i,j) when the added result exceeds the transmittable amount of data, and an ith quantizer (20) is selected for the small blocks from a 0th up to a (j-1)th or jth small block, and an (i-1)th quantizer is selected for the small blocks coming thereafter.

6. An orthogonal transform coding apparatus as claimed in Claim 2, wherein when there are n kinds of quantizers (20) and m small blocks included in one large block, and the amount of data in the jth small block of the ith quantizer is expressed as D(i,j), if D(i,j) ≥ D(i-1,j) when 1 ≤ i < n, said data amount storing means successively stores S(i,j) = D(i,j) - D(i-1,j) for said m small blocks in a memory with regard to i, and simultaneously stores a sum AD(i) which is a total amount of data of said m small blocks corresponding to each quantizer with regard to i, and the quantizer selecting means (19) first compares said sum AD(i) with the transmittable amount of data with regard to i where 1 ≤ i < n, and the maximum sum AD (K) not exceeding the transmittable amount of data and K are fetched, and then, to said maximum sum AD (K) are added S (k+1,j) in order of j = 0,1, ..., m-1 in a successive manner, j with respect to an equation S(k+1,j) when the added result exceeds the transmittable amount of data, and a (k+1)th quantizer is selected for the small blocks from a 0th to a (j-1)th or jth small block, and a kth quantizer is selected for the small blocks coming thereafter.

7. An orthogonal transform coding apparatus as claimed in Claim 3, wherein said data amount estimating means (18) roughly estimates the amount of data which is smaller than that needed to actually calculate the amount of data.

8. An orthogonal transform coding apparatus as claimed in Claims 1,2 or 3 wherein said quantizer selecting means (19) detects the dynamic range for each small block, and then sorts each small block into a plurality of groups according to said dynamic range, and then selects a quantizer having a large quantization width for small block groups having a small dynamic range, and transmits the thus obtained result together with information showing that each small block is included in a particular group.

9. An orthogonal transform coding apparatus as claimed in Claim 8, wherein the dynamic range detected by said quantizer selecting means (19) for each small block is represented by a maximum value of an absolute value of the orthogonally transformed components included in each small block.

10. An orthogonal transform coding apparatus as claimed in Claims 1,2 or 3, wherein for a luminance signal and two color difference signals, said quantizer selecting means (19) selects a quantizer with a large quantization width for signals in which it is difficult to recognize visual picture degradation and a quantizer with a small quantization width for signals in which it is easy to recognize visual picture degradation.

11. An orthogonal transform coding apparatus as claimed in Claim 1 or 2, wherein when writing a difference of quantizer for the small blocks different in a dynamic range from each other or for a luminance signal and two color difference signals and the amount of data for each small block in a memory, said quantizer selecting means (19) controls a writing address or reading address of the memory for every small block according to the difference of the quantizer thus written.

12. An orthogonal transform coding apparatus as claimed in Claims 1,2 or 3, wherein said transmission means rearranges the quantized values of a small block in a transmission region, in the order from a low frequency value to a high frequency value in both horizontal and vertical directions so as to include all non-zero values with a quantized value representing a lowest frequency component as one apex and transmits only a coded word of quantized values included in the transmission region and information of the transmission region.

13. An orthogonal transform coding apparatus as claimed in Claims 1,2 or 3, wherein said transmission means (22) rearranges the quantized values of a small block in the order from a lowest frequency value to a highest frequency value in both horizontal and vertical directions and transmits a coded word of quantized values representing from a lowest frequency component up to a highest frequency component in both horizontal and vertical directions in the order from a coded word of quantized values representing the low frequency value, and fails to transmit a code word of quantized values coming after the quantized value representing a highest non-zero frequency value using an end signal or information capable of determining a position of a last quantized value.

14. An orthogonal transform coding apparatus as claimed in Claim 1 or 2, wherein said variable length encoding means (21) encodes a quantized value with a code length 1 for a quantized value 0 and the data amount estimating means

(18) calculates an amount of the coded quantized values in the small blocks of one quantizer according to the equation:

$$\Sigma\ (Ni\text{-}1) + M$$

where, Ni is a code length of the ith quantized value, and M is the number of the quantized values to be transmitted.

15. An orthogonal transform coding apparatus as claimed in Claim 14, wherein said variable length encoding means (21) encodes a quantized value with a code length 2K + 1 or 2K for a quantized value whose absolute value is K, and said data amount estimating means (18) calculates an amount of data of the encoded quantized values in the small blocks of one quantizer according to the equation

$$2\ X\ \Sigma\ Ki + M$$

where Ki is the absolute value of the ith quantizer, and M is the number of the quantized values to be transmitted.

16. An orthogonal transform coding apparatus as claimed in Claim 13, wherein said variable length encoding means (21) encodes the quantized values in the order defined by said transmission means (22), and when the quantized value is 0, expresses the number of the quantized values of zero successively appeared thereto and the non-zero quantized values appeared first by one coded word.

17. An orthogonal transform coding apparatus as claimed in Claims 1,2 or 3, wherein said variable length encoding means (21) encodes orthogonally transformed components representing a low frequency level in a fixed length form and orthogonally transformed components representing a high frequency level in a variable length form.

18. An orthogonal transform coding apparatus as claimed in Claims 1,2 or 3, wherein said variable length encoding means (21) uses variable-length codes for orthogonally transformed components representing a low frequency level which are different from variable-length codes for orthogonally transformed components representing a high frequency level.

19. An orthogonal transform coding apparatus as claimed in Claims 1,2 or 3, wherein the quantization width is expressed as a power of 2 or as the product of a power of 2 and a specific constant, and a means for effecting the quantization or inverse quantization comprises one of a bit shifter and a combination of a bit shifter and a multiplier of said specific constant.

20. An orthogonal transform coding apparatus as claimed in Claims 1,2 or 3, wherein said quantizing means (20) sorts the orthogonally transformed components into r groups including from a group representing a high frequency level up to a group representing a low frequency level, and prepares s kinds of quantization widths, thus all of the quantizers performing quantization in combination of said r groups of the orthogonally transformed components with said s kinds of quantization widths.

21. An orthogonal transform coding apparatus as claimed in Claims 1,2 or 3, wherein said quantizing means (20) transmits an average value of quantization errors of non-zero quantized values for every small block and corrects inversely quantized values during decoding using said average value of quantization errors.

22. An orthogonal transform coding apparatus as claimed in Claims 1,2 or 3, wherein said quantizing means (20) quantizes signals placed at a same position on a picture plane using quantizers having different quantization characteristics for every frame or field.

Patentansprüche

1. Vorrichtung zur orthogonalen Transformationskodierung, welche umfaßt:

Großblock-Bildungsmittel (14) zum Zusammenstellen von Abtastwerten eines Eingabesignales zur Bildung eines großen Blockes von Abtastwerten;

Kleinblock-Bildungsmittel (15) zum Unterteilen des großen Blockes in eine Vielzahl von kleinen Blöcken; orthogonales Transformationsmittel (16) zum orthogonalen Transformieren der Abtastwerte in jedem der kleinen Blökke, um orthogonal transformierte Komponenten zu erhalten;
ein Datenmengen-Schätzmittel (18) zum Schätzen einer Datenmenge von kodierten Daten;
ein Quantisierer-Wahlmittel (19) zum Auswählen eines Quantisierers (20) aus der Vielzahl von Quantisierer-Arten entsprechend der durch das Datenmengen-Schätzmittel (18) geschätzten Datenmenge in solcher Weise, daß eine Gesamtdatenmenge kodierter Daten in dem großen Block in einen vorgegebenen Bereich fällt;
variables Längenkodiermittel (21) zum Kodieren von durch den durch das Quantisierer-Wahlmittel (19) gewählten Quantisierer quantisierten Daten, um aktuelle kodierte Daten zu erhalten; und
Übertragungsmittel (22) zum Übertragen der aktuellen kodierten Daten,

dadurch gekennzeichnet, daß: das Großblock-Bildungsmittel (14) Abtastwerte in einem Rahmen eines Eingabesignales zusammenstellt zur Bildung eines großen Blockes von Abtastwerten, der kleiner als der Rahmen ist;

das Datenmengen-Schätzmittel (18) eine Datenmenge von kodierten Daten schätzt, die durch das variable Längenkodieren der quantisierten Daten erreicht wird, die mindestens durch einen Teil der Vielzahl von Arten von Quantisierern (20) in jedem der Vielzahl von kleinen Blöcken erhalten wird, um eine Vielzahl von Datenmengenwerten entsprechend mindestens einem Teil der Vielzahl von Quantisierern zu erhalten mit Bezug auf die Vielzahl von kleinen Blöcken; und
das Quantisierer-Wahlmittel (19) aus der Vielzahl von Arten von Quantisierern (20) einen Quantisierer wählt, der eine optimale Datenmenge der kodierten Daten, mit Bezug auf jeden aus der Vielzahl von kleinen Blöcken, entsprechend den durch das Datenmengen-Schätzmittel (18) geschätzten Datenmengenwerten in solcher Weise ergibt, daß eine Gesamtdatenmenge kodierter Daten mit Bezug auf den großen Block eine optimale Datenmenge wird, die entweder eine maximale Datenmenge nicht größer als eine tatsächlich übertragbare Datenmenge oder eine minimale Datenmenge nicht kleiner als die tatsächlich übertragbare Datenmenge ist, und ein für den ausgewählten Quantisierer bezeichnendes Auswahlsignal ausgibt.

2. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 1, bei der das Datenmengen-Schätzmittel (18) ein Datenmengen-Speichermittel enthält zum Speichern der Vielzahl von durch das Datenmengen-Schätzmittel geschätzten Datenmengenwerten.

3. Vorrichtung nach Anspruch 1 oder 2, bei der das Quantisierer-Wahlmittel (19) zuerst unter n Arten von Quantisierern (20) einen Quantisierer findet, der eine n/2-größte Menge von kodierten Daten ergibt, wobei n die Anzahl der zu durchsuchenden Quantisierer ist, um einen optimalen Quantisierer unter der Vielzahl von Arten von Quantisierern zu finden, und dann bestimmt, daß die als nächstes zu suchenden möglichen Quantisierer nur Quantisierer sind, welche Mengen von kodierten Daten ergeben, die jeweils kleiner als die n/2-größte Datenmenge ist, falls die n/2-größte Datenmenge größer als eine übertragbare Datenmenge ist, oder nur Quantisierer, welche Mengen von kodierten Daten ergeben, die jeweils größer als die n/2-größte Datenmenge ist, falls die n/2-te Datenmenge kleiner als die übertragbare Datenmenge ist, wobei das Quantisierer-Wahlmittel diese Vorgänge wiederholt, bis ein optimaler auszuwählender Quantisierer gefunden ist.

4. Orthogonale Transformations-Kodiervorrichtung nach einem der Ansprüche 1, 2 oder 3, bei der das Quantisierer-Wahlmittel (19) Mittel enthält zum Unterteilen der kleinen, in einem großen Block enthaltenen Blöcke in eine vordere Hälfte, welche Quantisierer (20) von einem oberen bis zu einem j-ten enthält und eine hintere Hälfte, die den Rest enthält, und Mittel zum Auswählen eines Quantisierers von sowohl der vorderen wie der hinteren Hälfte, um so einander nächst-quantisierte Werte zu erzeugen, und Mittel zum Kodieren und Übertragen von Information der so ausgewählten Quantisierer in der vorderen und der hinteren Hälfte und der Zahl j.

5. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 2, bei der, wenn n mögliche Quantisierer und m kleine Blöcke in einem großen Block vorhanden sind, und die Datenmenge in dem j-ten kleinen Block des i-ten Quantisierers als $D(i,j)$ ausgedrückt wird, wobei $D(1,j) \geq D(i-1,j)$, wenn $1 \leq i < n$, das Datenmengen-Speichermittel zuerst $D(0,j)$ für die m kleinen Blöcke in einen Speicher speichert und dann, wenn $S(i,j) = D(i,j) - D(i-1,j)$ bei $1 \leq i < n$, das Datenmengen-Speichermittel aufeinanderfolgend $S(i,j)$ mit Bezug auf i in den Speicher speichert, und das Quantisierer-Wahlmittel (19) $D(0,j)$ in den m kleinen Blöcken von 0 bis m-1 mit Bezug auf j liest und aufeinanderfolgend addiert, und dann zu dem so addierten Ergebnis aufeinanderfolgend $S(i,j)$ in der Reihenfolge $S(0,0)$, $S(0,1)$, ..., $S(0,m-1)$, $S(1,0)$ ..., und $S(n-1,m-1)$ addiert werden, mit i und j mit Bezug auf die Gleichung von $S(i,j)$, wenn das addierte Ergebnis die übertragbare Datenmenge übersteigt und ein i-ter Quantisierer (20) für die kleinen Blöcke von einem 0-ten bis zu einem (j-1)-ten oder j-ten kleinen Block gewählt wird und ein (i-1)-ter Quantisierer

für die danach kommenden kleinen Blöcke gewählt wird.

6. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 2, bei der, wenn n Arten von Quantisierern (20) vorhanden sind und m kleine Blöcke in einem großen Block enthalten sind und die Datenmenge in dem j-ten kleinen Block des i-ten Quantisierers ausgedrückt wird als D(i,j), wenn $D(i,j) \geq D(i-1,j)$ mit $1 \leq i < n$, das Datenmengen-Speichermittel aufeinanderfolgend $S(i,j) = D(i,j) - D(i-1,j)$ für die m kleinen Blöcke in einem Speicher mit Bezug auf i speichert und gleichzeitig eine Summe AD(i) speichert, welche eine Gesamtdatensumme von m kleinen Blöcken entsprechend jedem Quantisierer mit Bezug auf i ist, und das Quantisierer-Wahlmittel (19) zuerst die Summe AD(i) mit der übertragbaren Datenmenge mit Bezug auf i vergleicht, wobei $1 \leq i < n$, und die maximale Summe AD(K), welche die übertragbare Datenmenge nicht übersteigt, und K geholt werden, und dann S(k+1,j) in der Reihenfolge von j = 0, 1, ..., m-1 aufeinanderfolgend zu der genannten Maximalsumme AD(K) addiert werden, dabei j mit Bezug auf eine Gleichung S(k+1,j) wenn die addierten Ergebnisse die übertragbare Datenmenge übersteigt, und ein (k+1)-ter Quantisierer für die kleinen Blöcke von einem 0-ten zu einem (j-1)-ten oder j-ten kleinen Block gewählt wird, und ein k-ter Quantisierer für die danach kommenden kleinen Blöcke gewählt wird.

7. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 3, bei der das Datenmengen-Schätzmittel (18) grob die Datenmenge abschätzt, die kleiner als die zum tatsächlichen Berechnen der Datenmenge benötigte ist.

8. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 1, 2 oder 3, bei der das Quantisierer-Wahlmittel (19) den Dynamikbereich für jeden kleinen Block erfaßt und dann jeden kleinen Block in eine Vielzahl von Gruppen entsprechend dem Dynamikbereich einsortiert, und dann einen Quantisierer mit einer großen Quantisierungsbreite wählt für Gruppen kleiner Blöcke mit einem kleinen Dynamikbereich und das so erhaltene Ergebnis zusammen mit Information überträgt, die zeigt, daß jeder kleiner Block in einer bestimmten Gruppe enthalten ist.

9. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 8, bei der der durch das Quantisierer-Wahlmittel (19) für jeden kleinen Block erfaßte Dynamikbereich dargestellt wird durch einen Maximalwert eines Absolutwertes der in jedem kleinen Block enthaltenen orthogonal transformierten Komponenten.

10. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 1, 2 oder 3, bei der das Quantisierer-Wahlmittel (19) für ein Luminanzsignal und zwei Farbdifferenzsignale einen Quantisierer mit einer großen Quantisierungsbreite wählt für Signale, bei denen es schwierig ist, visuelle Bildverschlechterung zu erkennen und einen Quantisierer mit enger Quantisierungsbreite für Signale, in denen es leicht ist, visuelle Bildverschlechterung zu erkennen.

11. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 1 oder 2, bei der beim Einschreiben einer Quantisierer-Differenz für die kleinen Blöcke, die sich in einem Dynamikbereich voneinander unterscheiden, oder für ein Luminanzsignal und zwei Farbdifferenzsignale, und der Datenmenge für jeden kleinen Block in einen Speicher das Quantisierer-Wahlmittel (19) eine Schreib- oder Leseadresse des Speichers für jeden kleinen Block entsprechend der so geschriebenen Quantisierer-Differenz steuert.

12. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 1, 2 oder 3, bei der das Übertragungsmittel die quantisierten Werte eines kleinen Blockes in einem Übertragungsbereich in der Reihenfolge von einem niedrigen Frequenzwert zu einem hohen Frequenzwert sowohl in horizontaler wie auch in vertikaler Richtung neu anordnet, um so alle von Null verschiedenen Werte einzuschließen, mit einem eine niedrigste Frequenzkomponente darstellenden quantisierten Wert als einem Scheitel, und nur ein kodiertes Wort von in dem Übertragungsbereich enthaltenen quantisierten Werten und Information des Übertragungsbereichs überträgt.

13. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 1, 2 oder 3, bei der das Übertragungsmittel (22) die quantisierten Werte eines kleinen Blockes in der Reihenfolge von einem niedrigsten Frequenzwert zu einem höchsten Frequenzwert sowohl in horizontaler wie auch in vertikaler Richtung neu anordnet und ein kodiertes Wort von quantisierten Werten überträgt, die von einer Niedrigstfrequenz-Komponente bis zu einer Höchstfrequenz-Komponente sowohl in Horizontal- wie in Vertikalrichtungen darstellen in der Reihenfolge von einem kodierten Wort von quantisierten Werten an, welche den Niedrigfrequenzwert darstellen, und dabei versagt, eine Kodewort von quantisierten Werten zu übertragen, welches nach dem quantisierten Wert kommt, der einen höchsten von Null verschiedenen Frequenzwert darstellt, unter Benutzung eines Endsignals oder einer Information, die zum Bestimmen einer Position eines letzten quantisierten Wertes fähig ist.

14. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 1 oder 2, bei der das variable Längenkodiermittel (21) einen quantisierten Wert mit einer Kodelänge 1 für einen quantisierten Wert 0 kodiert und das Datenmengen-

Schätzmittel (18) eine Menge der kodierten quantisierten Werte in den kleinen Blöcken von einem Quantisierer errechnet nach der Gleichung:

$$\Sigma (Ni-1) + M,$$

wobei Ni eine Kodelänge des i-ten quantisierten Wertes und M die Zahl der zu übertragenden quantisierten Werte ist.

15. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 14, bei der das variable Längenkodiermittel (21) einen quantisierten Wert mit einer Kodelänge 2K + 1 oder 2K kodiert für einen quantisierten Wert, dessen Absolutwert K ist, und das Datenmengen-Schätzmittel (18) eine Datenmenge der kodierten quantisierten Werte in den kleinen Blöcken eines Quantisierers errechnet gemäß der Gleichung:

$$2 \times \Sigma Ki + M,$$

wobei Ki der Absolutwert des i-ten Quantisierers und M die Anzahl der zu übertragenden quantisierten Werte ist.

16. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 13, bei der das variable Längenkodiermittel (21) die quantisierten Werte in der durch das Übertragungsmittel (22) definierten Reihenfolge kodiert, und, wenn der quantisierte Wert 0 ist, die Anzahl der quantisierten Nullwerte, die aufeinanderfolgend dazu auftreten, und den als erstes erscheinenden von Null verschiedenen quantisierten Wert durch ein kodiertes Wort ausdrückt.

17. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 1, 2 oder 3, bei der das variable Längenkodiermittel (21) orthogonal transformierte Komponenten, die einen Niedrigfrequenzpegel darstellen, in einer Festlängenform kodiert, und orthogonal transformierte Komponenten, die einen Hochfrequenzpegel darstellen, in einer variablen Längenform kodiert.

18. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 1, 2 oder 3, bei der das variable Längenkodiermittel (21) variable Längenkodes für einen Niedrigfrequenzpegel darstellende orthogonal transformierte Komponenten benutzt, die sich unterscheiden von variablen Längenkodes für orthogonal transformierte Komponenten, welche einen Hochfrequenzpegel darstellen.

19. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 1, 2 oder 3, bei der die Quantisierungsbreite als eine Potenz von 2 oder als das Produkt einer Potenz von 2 mit einer bestimmten Konstante ausgedrückt wird, und ein Mittel zum Bewirken der Quantisierung oder der inversen Quantisierung jeweils einen Bitschieber oder eine Kombination aus einem Bitschieber und einem Multiplikator für die bestimmte Konstante umfaßt.

20. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 1, 2 oder 3, bei der das Quantisierungsmittel (20) die orthogonal transformierten Komponenten in r Gruppen sortiert, welche einschließen von einer Gruppe, die einen Hochfrequenzpegel darstellt bis zu einer Gruppe, die einen Niedrigfrequenzpegel darstellt und s Arten von Quantisierungsbreiten bereitstellt, so daß alle Quantisierer eine Quantisierung ausführen in Kombination der r Gruppen der orthogonal transformierten Komponenten mit den s Arten von Quantisierungsbreiten.

21. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 1, 2 oder 3, bei der das Quantisierungsmittel (20) einen Durchschnittswert aus Quantisierungsfehlern von von Null verschiedenen quantisierten Werten für jeden kleinen Block überträgt und invers quantisierte Werte während des Dekodierens unter Benutzung des Durchschnittswerts von Quantisierungsfehlern korrigiert.

22. Orthogonale Transformations-Kodiervorrichtung nach Anspruch 1, 2 oder 3, bei der das Quantisierungsmittel (20) an der gleichen Position einer Bildebene plazierte Signale quantisiert unter Benutzung von Quantisierern mit unterschiedlichen Quantisierungs-Kennwerten für jeden Rahmen oder jedes Feld.

Revendications

1. Appareil de codage de transformation orthogonale comprenant :

un moyen de grand bloc (14) pour assembler des valeurs d'échantillonnage d'un signal d'entrée pour former un grand bloc de valeurs échantillonnées ;
un moyen de petit bloc (15) pour diviser ledit grand bloc en une plus pluralité de petits blocs ;
un moyen de transformation orthogonale (16) pour transformer orthogonalement les valeurs d'échantillonnage de chacun des petits blocs pour obtenir des composantes transformées orthogonalement ;
une pluralité de types de quatifieurs (20) chacun pour quantifier les composantes transformées orthogonalement pour obtenir des données quantifiées ;
un moyen d'estimation de quantité de données (18) pour estimer une quantité de données des données codées ;
un moyen de sélection de quantifieur (19) pour sélectionner un quantifieur (20) parmi la pluralité de types de quantifieurs selon la quantité de données estimée par le moyen d'estimation de quantité de données (18) pour qu'un total de quantité de données de données codées dans le grand bloc soit dans un intervalle prédéterminé ;
un moyen de codage de longueur variable (21) pour coder des données quantifiées par le quantifieur (20) sélectionnées par ledit moyen de sélection de quantifieur (19) pour obtenir des données codées réelles ; et
un moyen de transmission (22) pour transmettre les données codées réelles,

caractérisé en ce que : ledit moyen de grand bloc (14) assemble des valeurs d'échantillonnage dans une trame d'un signal d'entrée pour former un grand bloc de valeurs échantillonnées qui est plus petit que la trame ;

ledit moyen d'estimation de quantité de données (18) estime une quantité de données de données codées qui serait obtenue en codant en longueur variable les données quantifiées, quantifiées par au moins une partie de la pluralité de types de quantifieurs (20) dans chacun de la pluralité de petits blocs pour obtenir une pluralité de valeurs de quantité de données correspondant à ladite au moins une partie de la pluralité de quantifieurs par rapport à la pluralité de petits blocs ; et
ledit moyen de sélection de quantifieur (19) sélectionne, parmi la pluralité de types de quantifieurs (20), un quantifieur qui donne une quantité de données optimum des données codées par rapport à chacune de la pluralité de petits blocs selon les valeurs de quantité de données estimées par le moyen d'estimation de quantité de données (18) de sorte qu'une quantité de données totale de données codées par rapport à un grand bloc devient une quantité de données optimum qui est soit une quantité de données maximum pas plus grande qu'une quantité de données réellement transmissible soit une quantité de données minimum pas plus petite que la quantité de données réellement transmissible, et fournit un signal de sélection indicateur du quantifieur sélectionné.

2. Appareil de codage de transformation orthogonale selon la revendication 1, dans lequel le moyen d'estimation de quantité de données (18) comprend un moyen de stockage de quantité de données pour stocker la pluralité de valeurs de quantité de données estimées par le moyen d'estimation de quantité de données.

3. Appareil de codage de transformation orthogonale selon la revendication 1 ou 2, dans lequel ledit moyen de sélection de quantifieur (19) trouve d'abord, parmi n types de quantifieurs (20), un quantifieur qui donne une n/2-ième plus grande quantité de données codées, où n est le nombre de quantifieurs à rechercher pour trouver un quantifieur optimum parmi la pluralité de types de quantifieurs, et ensuite détermine que des candidats de quantifieur à rechercher ne sont ensuite que des quantifieurs qui donnent des quantités de données codées chacune étant plus petite que la n/2-ième plus grande quantité de données si la n/2-ième quantité de données est plus grande qu'une quantité de données transmissible ou seulement des quantifieurs qui donnent des quantités de données codées étant chacune plus grande que les n/2-ième plus grandes quantités de données si les n/2-ième quantités de données sont plus petites que la quantité de données transmissible, ledit moyen de sélection de quantifieur répétant ces opérations jusqu'à ce qu'un quantifieur optimum à sélectionner soit trouvé.

4. Appareil de codage de transformation orthogonale selon la revendication 1, 2 ou 3, dans lequel ledit moyen de sélection de quantifieur (19) comprend un moyen pour diviser les petits blocs compris dans un grand bloc en une première moitié comprenant des quantifieurs (20) à partir d'un début jusqu'à un j-ième et une dernière moitié comprenant le reste, et un moyen pour sélectionner un quantifieur à partir de chacune de la première moitié de la dernière moitié afin de produire des valeurs quantifiées les plus proches les unes des autres, et un moyen pour coder et transmettre des informations des quantifieurs ainsi sélectionnés dans les première et dernière moitiés et du nombre j.

5. Appareil de codage de transformation orthogonale selon la revendication 2, dans lequel lorsqu'il y a n candidats de quantifieur et m petits blocs dans un grand bloc, et la quantité de données dans le j-ième petit bloc du i-ième

quantifieur est exprimée par D(i, j) si D(i, j) ≥ D(i - 1, j) lorsque 1 ≤ i < n, ledit moyen de stockage de quantité de données stocke d'abord D(o, j) pour lesdits m petits blocs dans une mémoire, et ensuite, si S(i, j) = D(i, j) - D(i - 1, j) lorsque 1 ≤ i < n, ledit moyen de stockage de quantité de données stocke successivement S(i, j) dans ladite mémoire en ce qui concerne i, et ledit moyen de sélection de quantifieur (19) lit et additionne successivement D (o, j) dans lesdits m petits blocs de O à m - 1 en ce qui concerne j, et ensuite, pour le résultat ainsi ajouté sont successivement ajoutés S(i, j) dans l'ordre de S(0, 0), S(0, 1)..., S(0, m - 1), S(1, 0)..., et S(n - 1, m - 1), i et j par rapport à l'équation S(i, j) lorsque le résultat ajouté dépasse la quantité de données transmissible, et un i-ième quantifieur (20) est sélectionnée pour de petits blocs à partir du 0-ième jusqu'au (j - 1)-ième ou j-ième petit bloc, et un (i - 1)-ième quantifieur est sélectionné pour le petit bloc venant ensuite.

6. Appareil de codage de transformation orthogonale selon la revendication 2, dans lequel lorsqu'il y a n types de quantifieurs (20) et m petits blocs compris dans un grand bloc, et la quantité de données dans le j-ième petit bloc du i-ième quantifieur est exprimée par D(i, j), si D(i, j) ≥ D(i - 1, j) lorsque 1 ≤ i < n, ledit moyen de stockage de quantité de données stocke successivement S(i, j) = D(i, j) - D(i - 1, j) pour lesdits m blocs dans une mémoire en ce qui concerne i, et stocke simultanément une somme AD(i) qui est une quantité totale de données desdits m petits blocs correspondant à chaque quantifieur en ce qui concerne i, et le moyen de sélection de quantifieur (19) compare d'abord la somme AD(i) avec la quantité de données transmissible en ce qui concerne i où 1 ≤ i < n, et la somme maximum AD(K) n'excédant pas la quantité de données transmissible et K sont cherchés, et puis, à ladite somme maximum AD(K) sont ajoutés S(K + 1, j) dans l'ordre de j = 0, 1,..., m - 1 d'une manière successive, j par rapport à une équation (S(K + 1, j) lorsque le résultat à ajouter dépasse la quantité de données transmissible, et un (K + 1)-ième quantifieur est sélectionné pour les petits blocs du 0-ième à un (j - 1)-ième ou j-ième petit bloc, et un K-ième quantifieur est sélectionné pour les petits blocs venant ensuite.

7. Appareil de codage de transformation orthogonale selon la revendication 3, dans lequel ledit moyen d'estimation de quantité de données (18) estime approximativement la quantité de données qui est plus petite que celle nécessaire pour calculer réellement la quantité de données.

8. Appareil de codage de transformation orthogonale selon la revendication 1, 2 ou 3, dans lequel ledit moyen de sélection de quantifieur (19) détecte l'intervalle dynamique pour chaque petit bloc, et ensuite trie chaque petit bloc en une pluralité de groupes selon ledit intervalle dynamique, et puis sélectionne un quantifieur ayant une grande largeur de quantification pour de petits groupes de blocs ayant un petit intervalle dynamique, et transmet le résultat ainsi obtenu ainsi que des informations montrant que chaque petit bloc est compris dans un groupe particulier.

9. Appareil de codage de transformation orthogonale selon la revendication 8, dans lequel l'intervalle dynamique détecté par ledit moyen de sélection de quantifieur (19) pour chaque petit bloc est représenté par une valeur maximum d'une valeur absolue de la composante transformée orthogonalement comprise dans chaque petit bloc.

10. Appareil de codage de transformation orthogonale selon la revendication 1, 2 ou 3, dans lequel pour un signal de luminance et deux signaux de différence de couleur, ledit moyen de sélection de quantifieur (19) sélectionne un quantifieur avec une grande largeur de quantification pour des signaux dans lesquels il est difficile de reconnaître une dégradation d'image visuelle et un quantifieur avec une petite largeur de quantification pour des signaux dans lesquels il est facile de reconnaître une dégradation d'image visuelle.

11. Appareil de codage de transformation orthogonale selon la revendication 1 ou 2, dans lequel lorsque l'écriture d'une différence de quantifieur pour les petits blocs différents dans un intervalle dynamique l'un de l'autre ou pour un signal de luminance et deux signaux de différence de couleur et la quantité de données pour chaque petit bloc dans une mémoire, ledit moyen de sélection de quantifieur (19) commande une adresse d'écriture ou une adresse de lecture de la mémoire pour chaque petit bloc selon la différence de quantifieur ainsi écrite.

12. Appareil de codage de transformation orthogonale selon la revendication 1, 2 ou 3, dans lequel ledit moyen de transmission réarrange la valeur quantifiée d'un petit bloc dans une zone de transmission, dans l'ordre à partir d'une valeur basse fréquence jusqu'à une valeur haute fréquence dans les deux directions horizontale et verticale afin d'inclure toutes les valeurs non nulles avec une valeur quantifiée représentant la composante de plus basse fréquence comme un sommet et ne transmet qu'un mot codé des valeurs quantifiées comprises dans la zone de transmission et des informations de la zone de transmission.

13. Appareil de codage de transformation orthogonale selon la revendication 1, 2 ou 3, dans lequel ledit moyen de transmission (22) réarrange les valeurs quantifiées d'un petit bloc dans l'ordre à partir de la plus basse valeur de

fréquence jusqu'à la plus haute valeur de fréquence dans les directions horizontale et verticale et transmet un mot codé de valeur quantifiée représentant à partir d'une plus basse composante de fréquence jusqu'à une plus haute composante fréquence dans les deux directions horizontale et verticale dans l'ordre à partir d'un mot codé de valeurs quantifiées représentant la valeur basse fréquence, et ne réussit pas à transmettre un mot de code de valeur quantifiée venant après la valeur quantifiée représentant une plus haute valeur de fréquence non nulle utilisant un signal de fin et des informations capables de déterminer une position d'une dernière valeur quantifiée.

14. Appareil de codage de transformation orthogonale selon la revendication 1 ou 2, dans lequel ledit moyen de codage de longueur variable (21) code une valeur quantifiée avec une longueur de code 1 pour une valeur quantifiée 0 et le moyen d'estimation de quantité de données (18) calcule une quantité de valeurs quantifiées codées dans les petits blocs d'un quantifieur selon l'équation :

$$\Sigma\,(Ni - 1) + M$$

où, Ni est une longueur de code de la i-ième valeur quantifiée, et M est le nombre de valeurs quantifiées à transmettre.

15. Appareil de codage de transformation orthogonale selon la revendication 14, dans lequel ledit moyen de codage de longueur variable (21) code une valeur quantifiée avec une longueur de code 2K + 1 ou 2K pour une valeur quantifiée dont la valeur absolue est K, et ledit moyen d'estimation de quantité de données (18) calcule une quantité de données des valeurs quantifiées codées dans le petit bloc d'un quantifieur selon l'équation

$$2 \times \Sigma\, Ki + M$$

où Ki est la valeur absolue du i-ième quantifieur, et M est le nombre de valeurs quantifiées à transmettre.

16. Appareil de codage de transformation orthogonale selon la revendication 13, dans lequel ledit moyen de codage de longueur variable (21) code les valeurs quantifiées dans l'ordre défini par ledit moyen de transmission (22), et lorsque la valeur quantifiée est 0, exprime le nombre de valeurs quantifiées de zéro apparues successivement sur celui-ci et les valeurs quantifiées non nulles apparues d'abord par un mot codé.

17. Appareil de codage de transformation orthogonale selon la revendication 1, 2 ou 3, dans lequel ledit moyen de codage de longueur variable (21) code les composantes transformées orthogonalement représentant un niveau basse fréquence dans une forme de longueur fixe et des composantes transformées orthogonalement représentant un niveau haute fréquence dans une forme de longueur variable.

18. Appareil de codage de transformation orthogonale selon la revendication 1, 2 ou 3, dans lequel ledit moyen de codage de longueur variable (21) utilise des codes de longueur variable pour des composantes transformées orthogonalement représentant un niveau basse fréquence qui sont différents des codes de longueur variable pour des composantes transformées orthogonalement représentant un niveau haute fréquence.

19. Appareil de codage de transformation orthogonale selon la revendication 1, 2 ou 3, dans lequel la largeur de quantification est exprimée par une puissance de 2 ou par le produit d'une puissance de 2 et d'une constante spécifique, et un moyen pour effectuer la quantification ou la quantification inverse comprend un dispositif de décalage binaire et une combinaison d'un dispositif de décalage binaire et un multiplieur de ladite constante spécifique.

20. Appareil de codage de transformation orthogonale selon la revendication 1, 2 ou 3, dans lequel ledit moyen de quantification (20) trie les composantes transformées orthogonalement en r groupes se composant à partir d'un groupe représentant un niveau haute fréquence jusqu'à un groupe représentant un niveau basse fréquence, et prépare s types de largeurs de quantification, ainsi tous les quantifieurs réalisant une quantification en combinaison desdits r groupes de composantes transformées orthogonalement avec lesdits s types de largeurs de quantification.

21. Appareil de codage de transformation orthogonale selon la revendication 1, 2 ou 3, dans lequel ledit moyen de quantification (20) transmet une valeur moyenne des erreurs de quantification de valeur quantifiées non nulles

pour chaque petit bloc et corrige des valeurs quantifiées inversement pendant le décodage utilisant ladite valeur moyenne des erreurs de quantification.

22. Appareil de codage de transformation orthogonale selon la revendication 1, 2 ou 3, dans lequel ledit moyen de quantification (20) quantifie des signaux placés à la même position sur un plan d'image utilisant des quantifieurs ayant des caractéristiques de quantification différentes pour chaque trame ou champ.

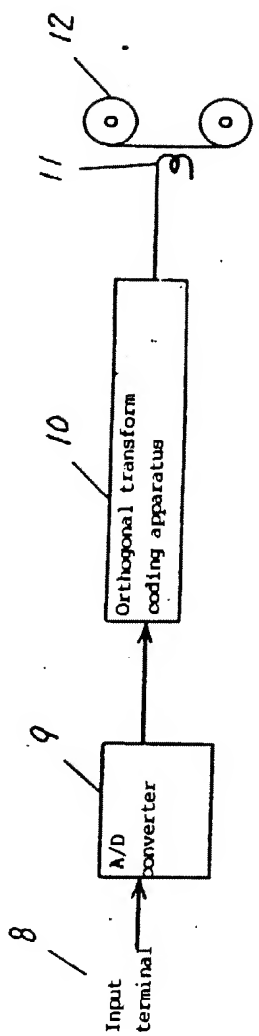

Input terminal
8
A/D converter
9
Orthogonal transform coding apparatus
10
11
12

Fig. 1

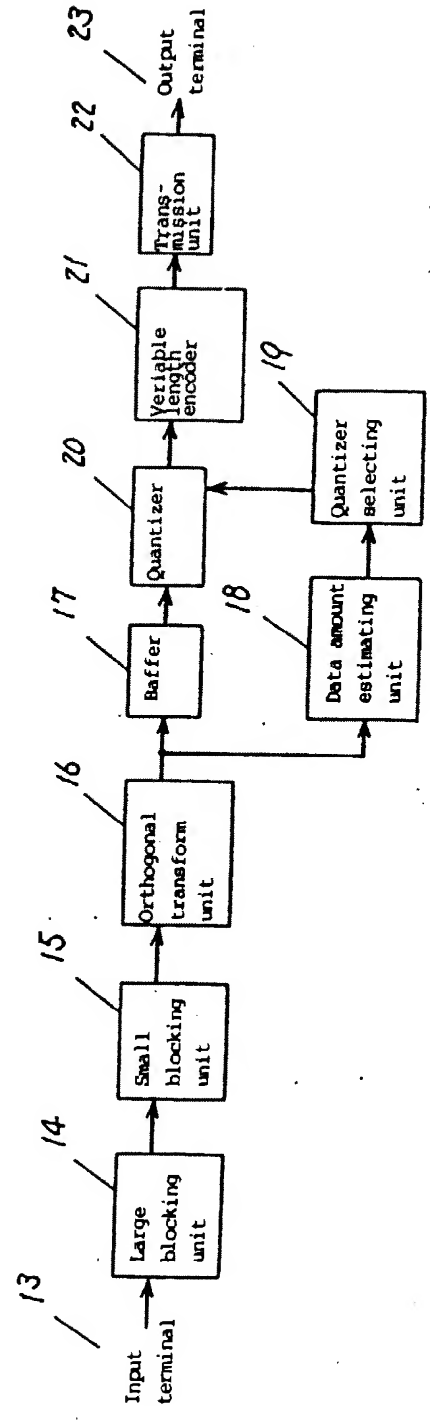

Input terminal
13
Large blocking unit
14
Small blocking unit
15
Orthogonal transform unit
16
Baffer
17
Data amount estimating unit
18
Quantizer
20
Quantizer selecting unit
19
Veriable length encoder
21
Trans-mission unit
22
Output terminal
23

Fig. 2

Fig. 3

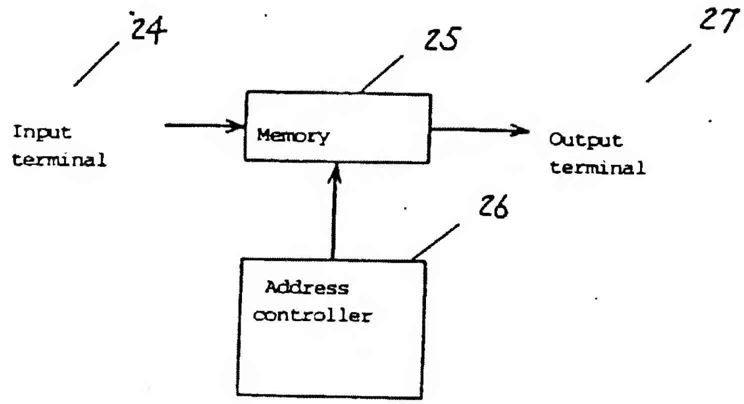
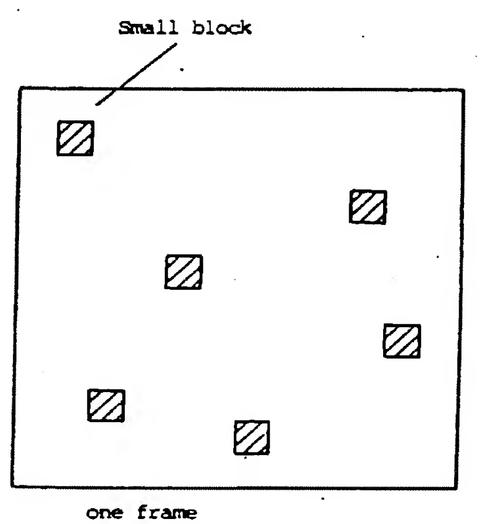

24
25
27
Input
terminal
Memory
Output
terminal
26
Address
controller

Fig. 4


Small block
one frame

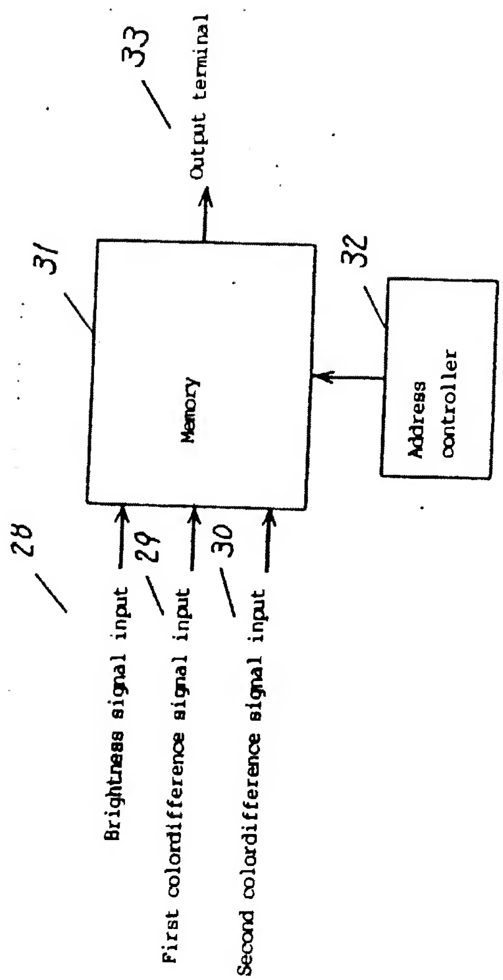

Brightness signal input
First colordifference signal input
Second colordifference signal input
Memory
Address controller
Output terminal
28
29
30
31
32
33

Fig. 5

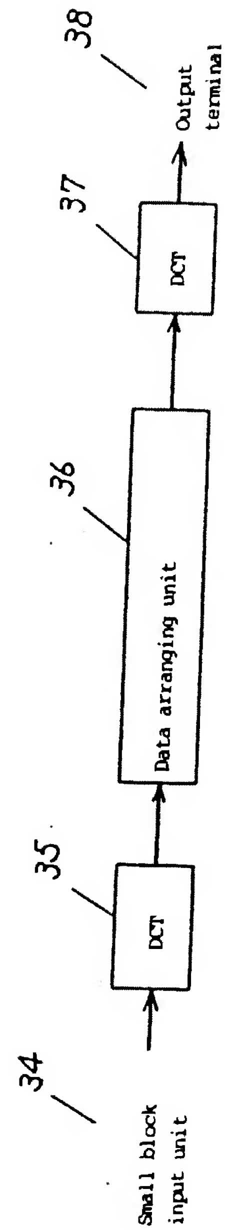

Small block input unit
DCT
Data arranging unit
DCT
Output terminal
34
35
36
37
38

Fig. 6

Fig. 7

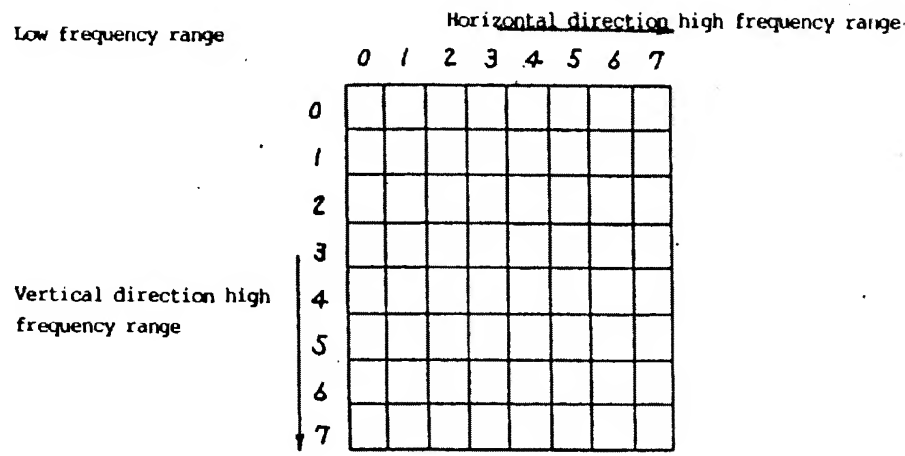

Low frequency range
Horizontal direction high frequency range
0 1 2 3 4 5 6 7
0 1 2 3 4 5 6 7
Vertical direction high frequency range

Fig. 8

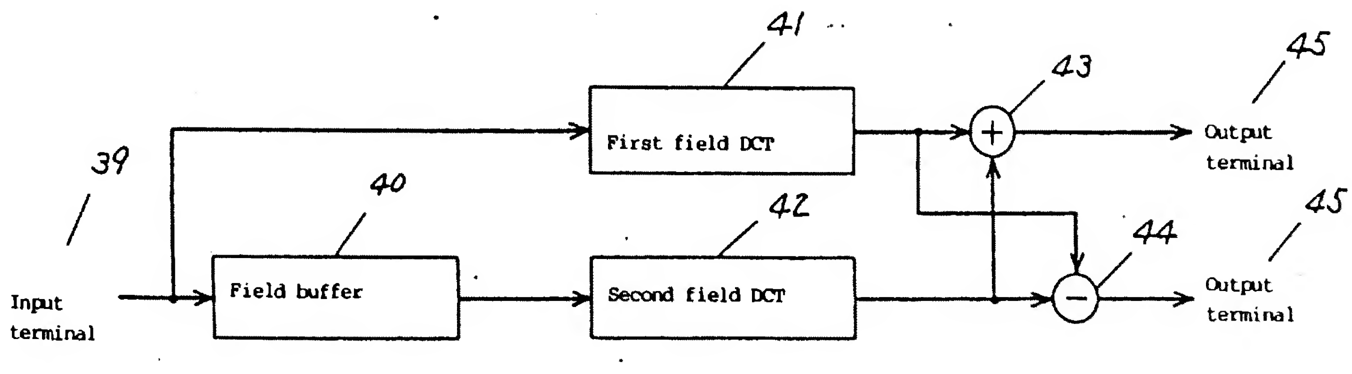
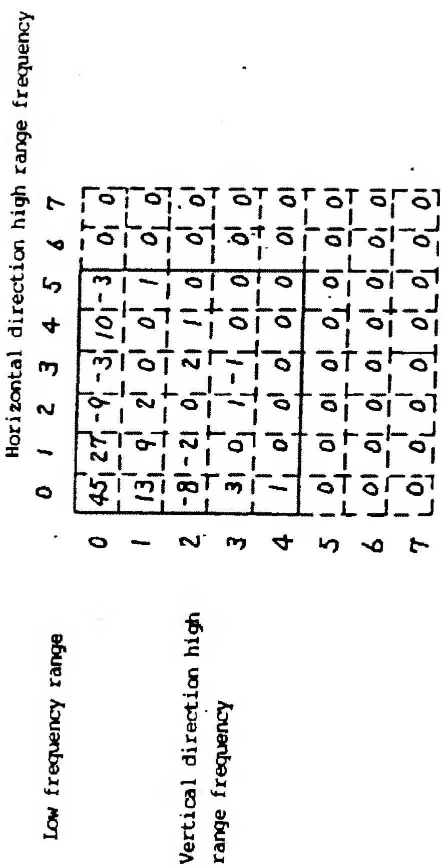

39
Input terminal
40
Field buffer
41
First field DCT
42
Second field DCT
43
44
45
Output terminal
45
Output terminal

Fig. 9



	0	1	2	3	4	5	6	7
0	45	27	-9	-3	10	-3	0	0
1	13	9	2	0	0	1	0	0
2	-8	-2	0	2	1	0	0	0
3	3	0	1	-1	0	0	0	0
4	1	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0

Fig. 10

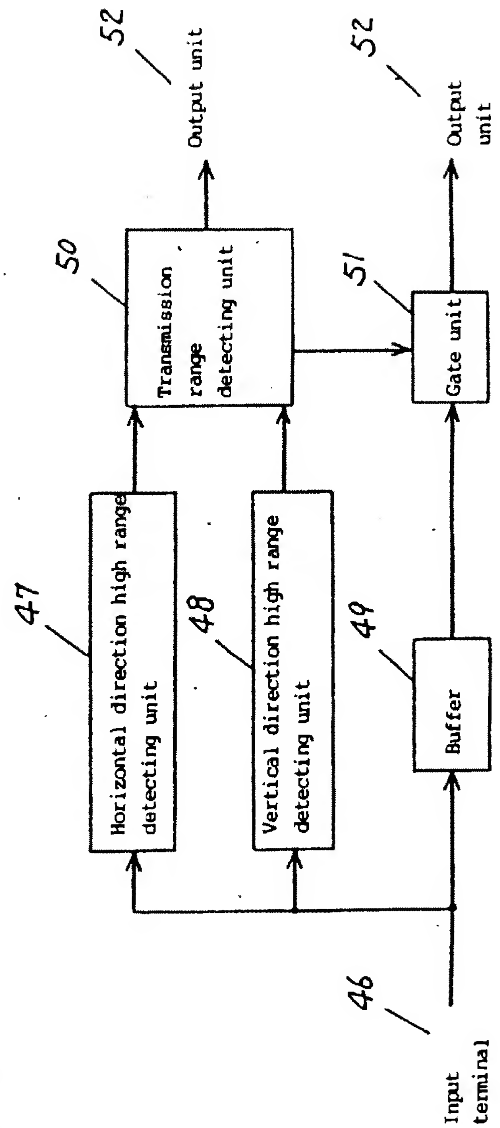


Fig. 11

Low frequency range

Horizontal direction high frequency range →

Vertical direction high frequency range ↓

	0	1	2	3	4	5	6	7
0	1	3	4	10	11	21	22	36
1	2	5	9	12	20	23	35	37
2	6	8	13	19	24	34	38	49
3	7	14	18	25	33	39	48	50
4	15	17	26	32	40	47	51	58
5	16	27	31	41	46	52	57	59
6	28	30	42	45	53	56	60	63
7	29	43	44	54	55	61	62	64

Fig. 12

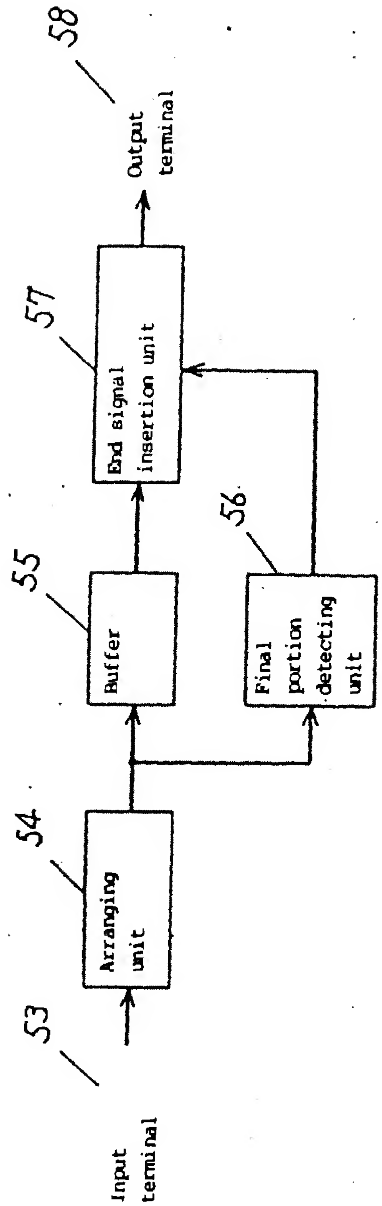

Input terminal
53
Arranging unit
54
Buffer
55
Final portion detecting unit
56
End signal insertion unit
57
Output terminal
58

Fig. 13

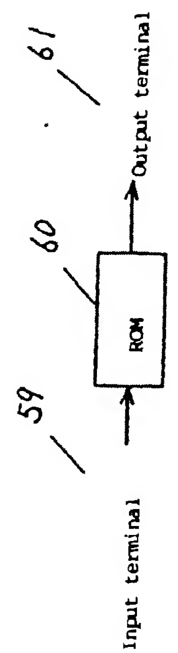

Input terminal
59
ROM
60
Output terminal
61

Fig. 14

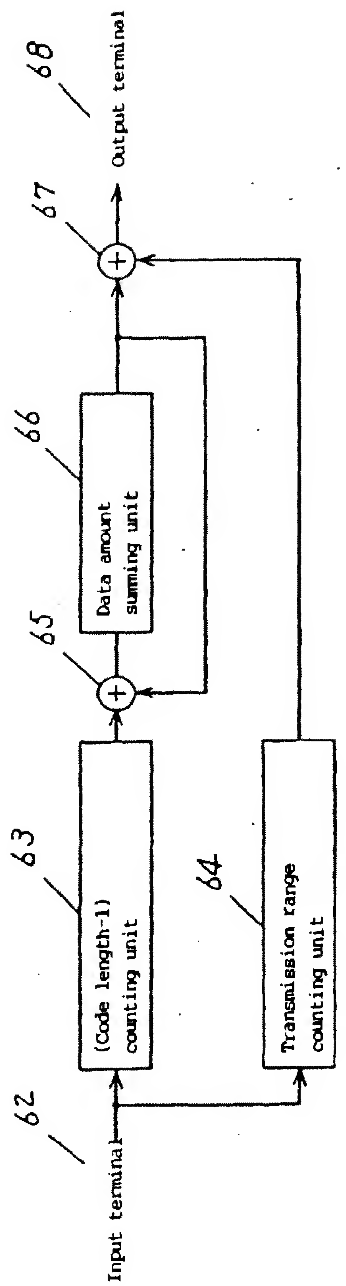

Input terminal
62
(Code length-1) counting unit
63
Transmission range counting unit
64
65
Data amount summing unit
66
67
Output terminal
68

Fig. 15

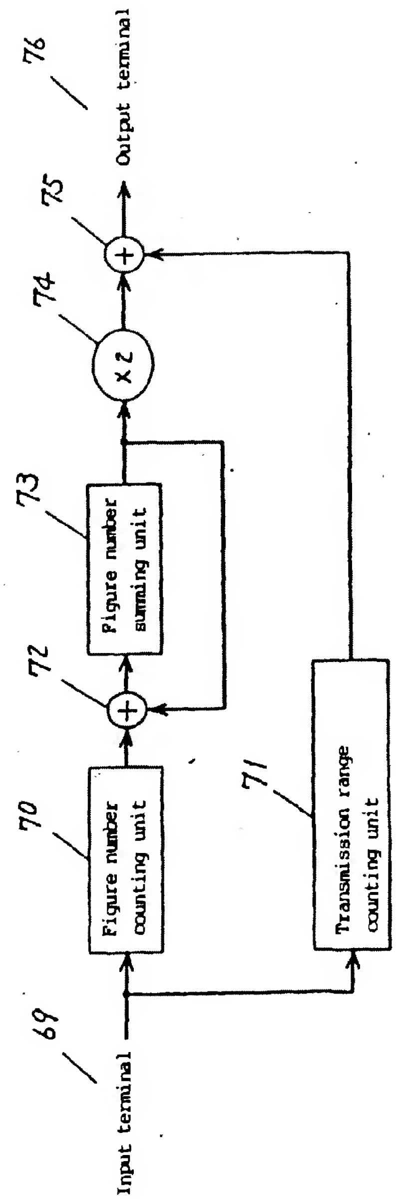

Input terminal
69
Figure number counting unit
70
Transmission range counting unit
71
72
Figure number summing unit
73
x 2
74
75
Output terminal
76

Fig. 16

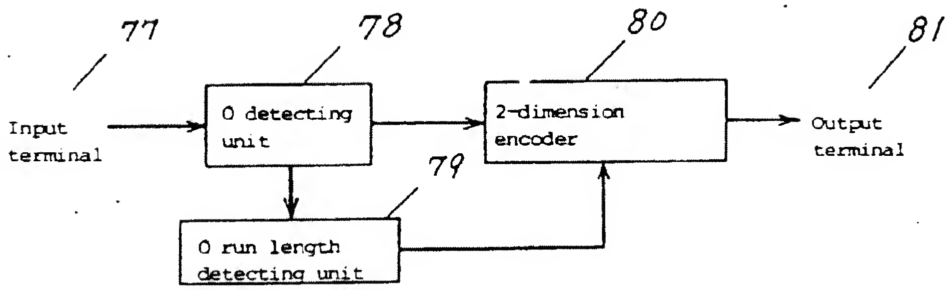

77
78
80
81
Input
terminal
0 detecting
unit
2-dimension
encoder
Output
terminal
79
0 run length
detecting unit

Fig. 17

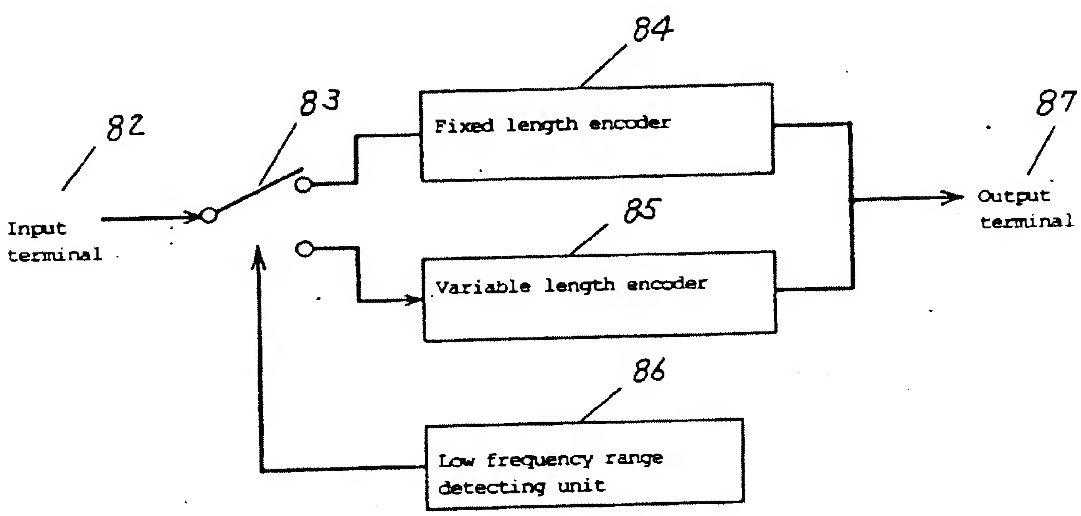

84
83
82
87
Fixed length encoder
Input
terminal
85
Output
terminal
Variable length encoder
86
Low frequency range
detecting unit

Fig. 18

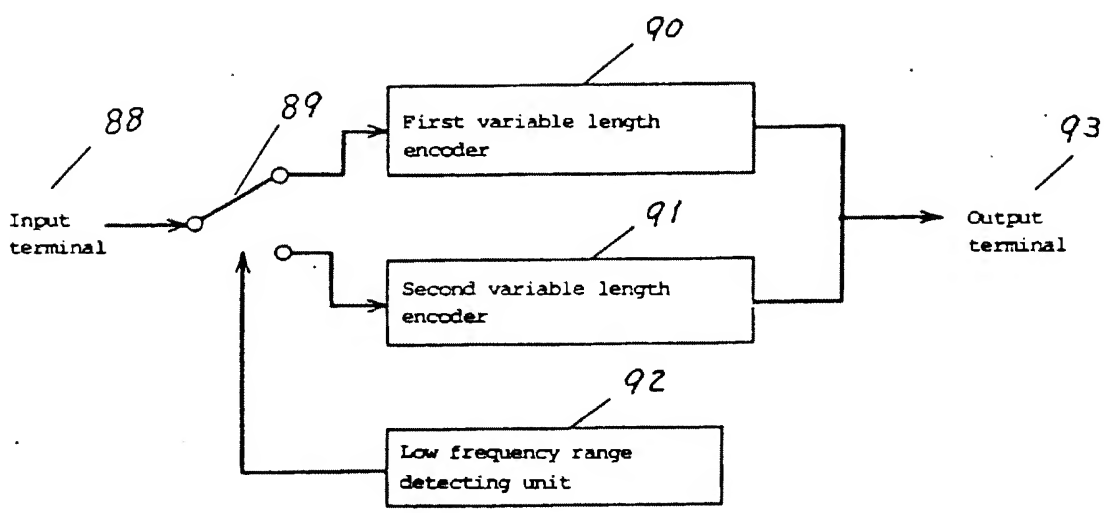

90
88
89
First variable length encoder
93
Input terminal
91
Output terminal
Second variable length encoder
92
Low frequency range detecting unit

Fig. 19

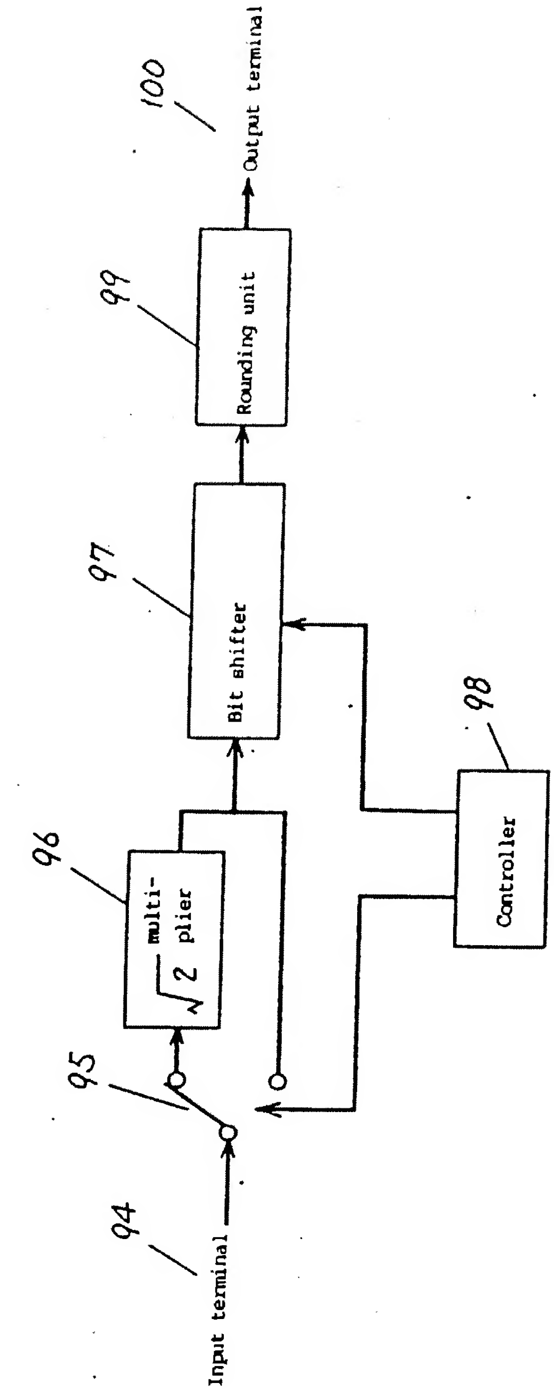

Input terminal
94
95
96
$\sqrt{2}$ multi-plier
97
Bit shifter
98
Controller
99
Rounding unit
100
Output terminal

Fig. 20

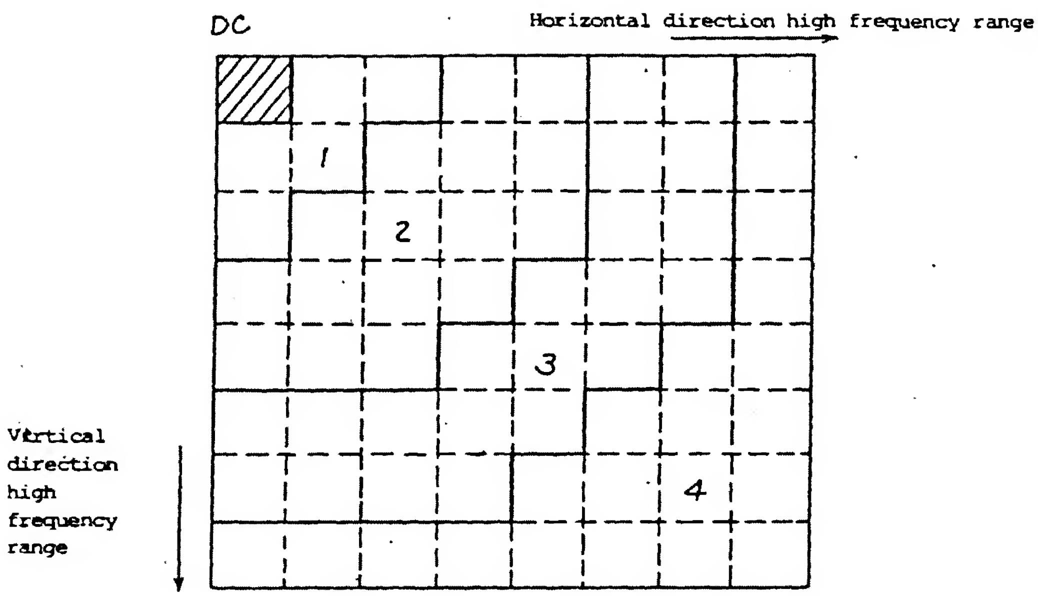
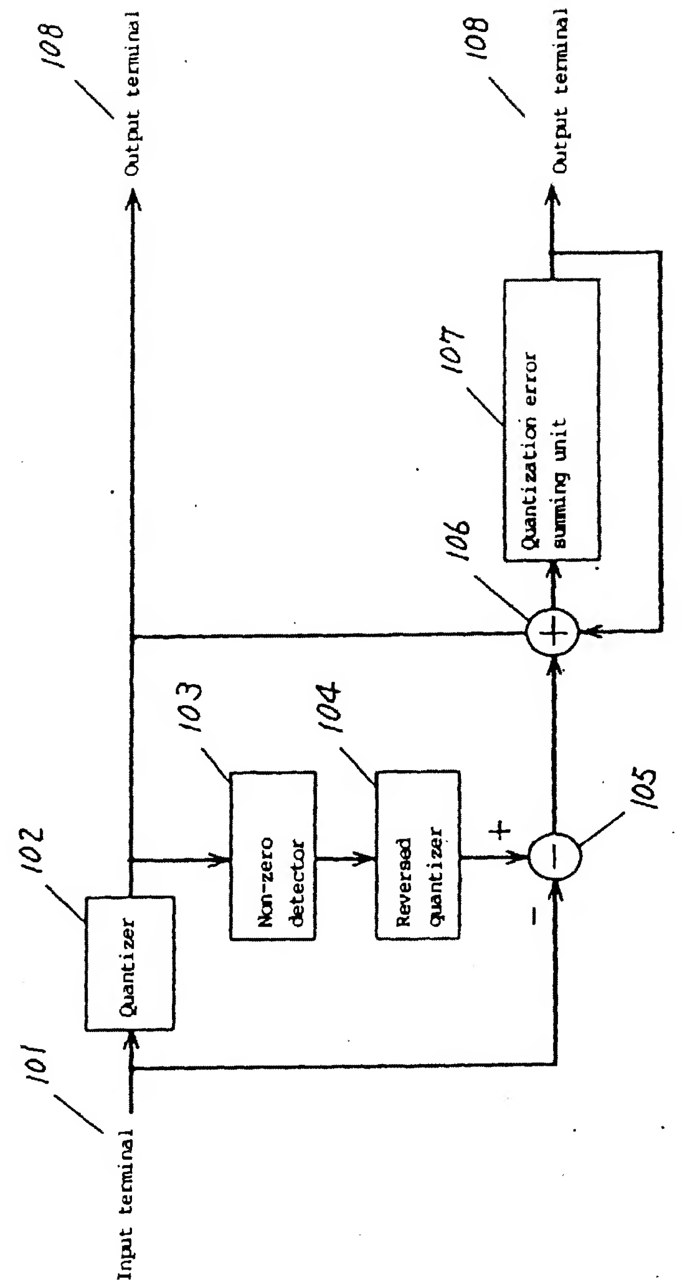

DC
Horizontal direction high frequency range
1
2
3
4
Vertical direction high frequency range

Fig. 21



Input terminal
101
Quantizer
102
Non-zero detector
103
Reversed quantizer
104
+
−
105
106
Quantization error summing unit
107
Output terminal
108
Output terminal
108

Fig. 22

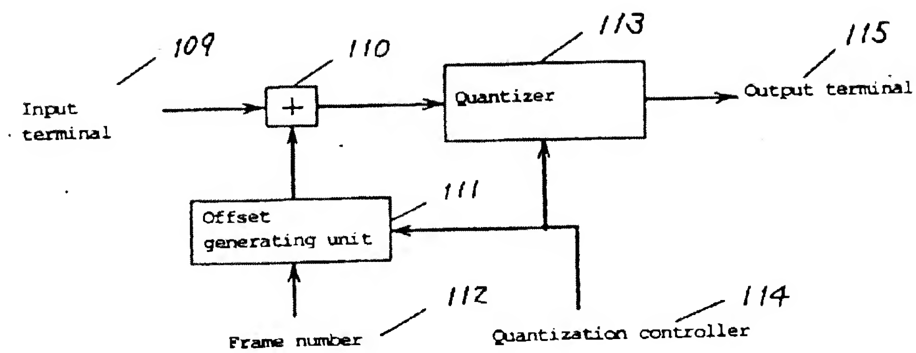

109
110
113
115
Input terminal
Quantizer
Output terminal
111
Offset generating unit
112
114
Frame number
Quantization controller

Fig. 23

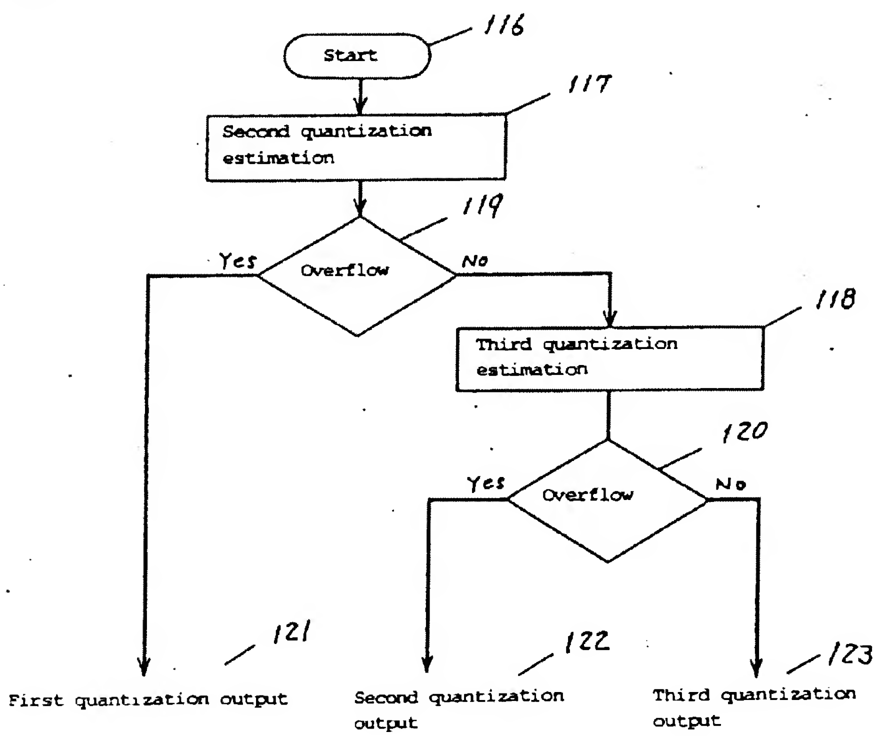
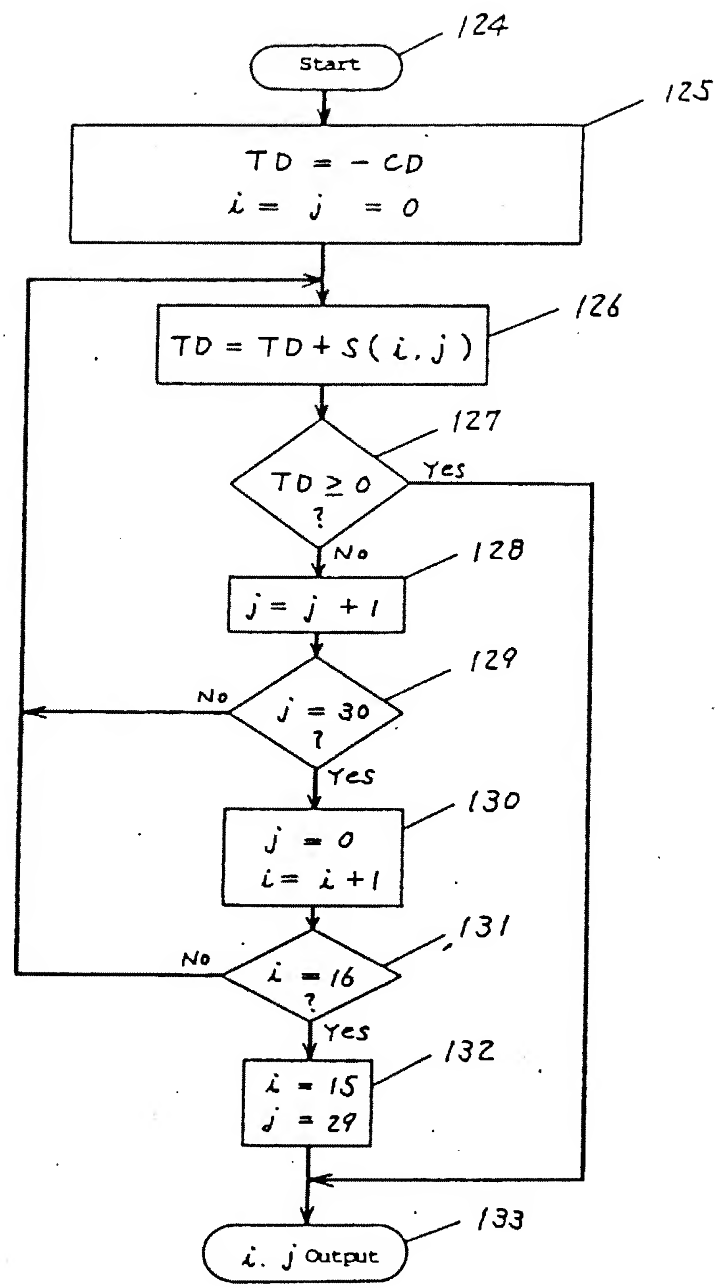

116
Start
117
Second quantization estimation
119
Yes
Overflow
No
118
Third quantization estimation
120
Yes
Overflow
No
121
122
123
First quantization output
Second quantization output
Third quantization output

Fig. 24



124
Start
125
TD = - CD
i = j = 0
126
TD = TD + S (i , j)
127
TD ≥ 0
?
Yes
No
128
j = j + 1
129
j = 30
?
No
Yes
130
j = 0
i = i + 1
131
i = 16
?
No
Yes
132
i = 15
j = 29
133
i . j Output

Fig. 25

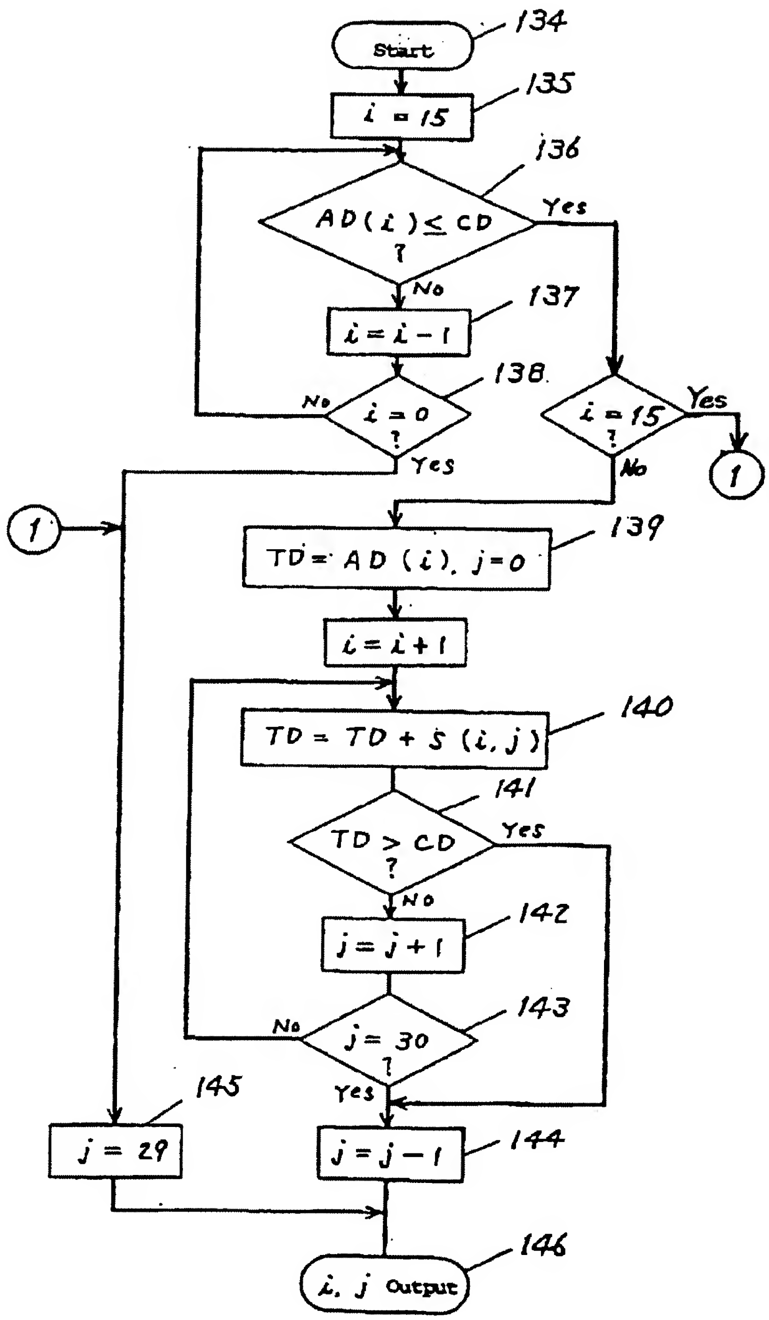

Start
134
i = 15
135
136
AD(i) ≤ CD ?
Yes
No
137
i = i - 1
138
i = 0 ?
No
Yes
i = 15 ?
Yes
No
1
1
TD = AD (i), j = 0
139
i = i + 1
TD = TD + S (i, j)
140
141
TD > CD ?
Yes
No
j = j + 1
142
j = 30 ?
143
No
Yes
145
j = 29
j = j - 1
144
146
i, j Output

Fig. 26

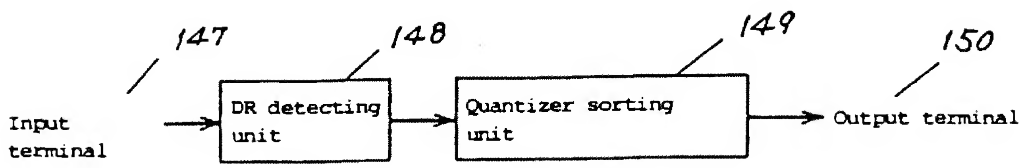


Fig. 27

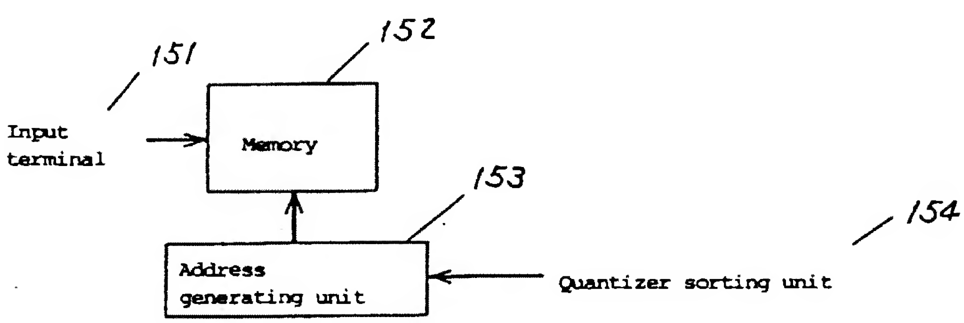


Fig. 28

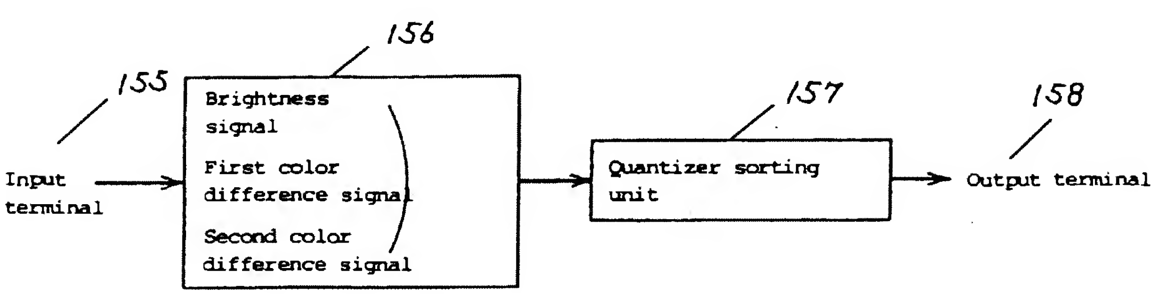
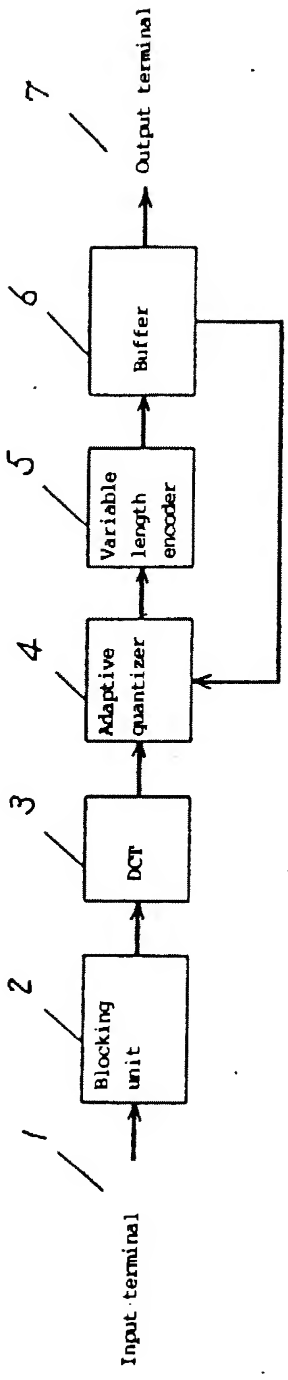


Fig. 29


Input terminal
1
Blocking unit
2
DCT
3
Adaptive quantizer
4
Variable length encoder
5
Buffer
6
Output terminal
7